Environmental Monitoring Plans and Programs

Geothermal Exploration Activities

Kilauea Middle East Rift Zone

Estate of James Campbell Property TMK 1-2-10:3

True/Mid-Pacific Geothermal Venture

January, 1989

Encl. (1)
Letter to DLNR
dtd:________.

TRUE GEOTHERMAL ENERGY COMPANY

895 WEST RIVER CROSS ROAD

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February 1, 1989

Department of Land & Natural Resources (DLNR)
State of Hawaii
P.O. Box 621
Honolulu, Hawaii 96809

Dear Sirs:

Subject: Geothermal Exploration Activities in the Kilauea Middle East Rift Zone (KMERZ)

The Board of Land & Natural Resources in a Decision & Order (D&O) of April 11, 1986, authorized exploration and development of geothermal resources on Campbell Estate property, Island of Hawaii, Puna District, TMK 1-2-10:3. The D&O prescribed procedures, data requirements and preparation of plans related to abated venting of geothermal wells, meteorological, air and noise monitoring, biological and archaeological surveys, and emergency plans, which were to be submitted to the Department of Land & Natural Resources for ministerial approval. Accordingly, all of the foregoing data requirements and plans are contained in Appendices "A" through "F" and are submitted herewith for approval.

Modification of the D&O prescribed procedures on "abated venting" is required in order to permit, as a standard industry procedural and technical requirement, the flow testing of each geothermal well that intersects a reservoir on a continuous basis for up to 30-45 days. The flow testing must be accomplished in the normal open-flow, well-production and operational mode in order to properly and accurately measure and evaluate the resource and the reservoir characteristics. This analysis is the basis for determining whether or not a geothermal reservoir is capable of producing and sustaining at open-flow rate sufficient geothermal energy to enable economic generation of electricity over the 25-30 year life of a power plant. Equally critical is the need to avoid the periodic shutting down or significant changes in flow rates of a geothermal well because of the resulting thermal shocks and damage which would accrue to the well bore and cementing.

There is no reasonable alternative known to be feasible in the industry that would allow reservoir analysis to the degree of accuracy that is necessary to justify the commitment and expenditure of millions of dollars for a power plant to utilize the resource. Flow testing is conducted under abated venting procedures which limit emissions to prescribed standards. Therefore, in accordance with D&O, the DLNR is requested to modify the restrictions imposed in the D&O which do not allow abated venting to be conducted on a continuous basis which is required in the 30-45 days of flow testing of each successful well and which is required to avoid serious damage to a geothermal well bore if the resource flow rate is periodically required to be shut down or significally changed.

Very truly yours,

TRUE GEOTHERMAL ENERGY COMPANY
(Operator for True/Mid-Pacific
Geothermal Venture)

H. A. True, III, Partner

Appendices: "A" Management Plan
"B" Air Quality and Meteorological Monitoring Plan
"C" Noise Monitoring Plan
"D" Biological Survey Report
"E" Archaeological Survey Report
"F" Emergency Plan

cc: Mid-Pacific Geothermal, Inc.
Estate of James Campbell

Environmental Monitoring Plans and Programs

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Management Plan

Geothermal Development Activities

(Exploration Phase)

Kilauea Middle East Rift Zone

Estate of James Campbell Property TMK 1-2-10:3

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January, 1989

Appendix A
Letter to DLNR
DATED:________

Management Plan

1. Access and Parking Control. A gate will be installed at the road entrance to the Campbell Estate Property at the juncture of the State road easement and the project site access road. Access will be limited to Project Personnel, officials of government agencies having regulatory responsibilities and such other visitors that may be admitted by project management. Since there is a potential for emissions of H_2S to exceed safe exposure levels during drilling, testing and venting, requiring immediate use of a full face gas mask by personnel at the drill site, no person with a beard will be allowed at the site during these operations. All non-project personnel admitted to the project site will be escorted by project personnel. A limited vehicle parking area will be prepared at the entrance to each drill site for utility vehicles and vehicles of project personnel and authorized visitors.

2. Safety. This section describes the over all policies of the Operator on safety which are designed to maintain the highest level of safety possible during project activities associated with exploration and development of geothermal resources. Also included is a description of potential events that could disrupt operations, cause injury or loss of life, or create health hazards and the additional measures and actions that will be taken to minimize the potential for such impacts.

Safety Policy. True Geothermal Energy Company, as operator, considers safety as one of its highest priorities. The company safety policy states that:

"True, owners, management and middle management, firmly believe that the continued success of any organization, or the successful completion of any project, can be achieved if it is done safely.

We realize the need to have quality people who have a positive attitude toward doing their jobs safely, with proficiency and with great concern for the safety and health of fellow workers."

In order to promote safety awareness, management is committed to a program of regular safety meetings at least once a month, for both the field and office staffs. At these meetings, personnel will receive training and lectures on the proper methods to handle hot valves, wellheads, pipelines, and bleed lines so that they will not become a source of injury. In addition to heat, H_2S safety will be emphasized. Personnel will be trained to use the emergency breathing equipment and recognize the danger signals of the presence of high levels of H_2S. First aid and C.P.R. sessions will be held periodically. Regular updates to the evacuation plans will be presented. A pyramid telephone calling system will be utilized to notify personnel of an evacuation order.

Many incentives are offered for safety such as monthly glove awards, yearly coverall awards, and yearly personal awards for drillers and toolpushers.

Specific Safety Considerations Related to the Well-Bore and Drill Rig. The drill rig will be equipped with proper blowout prevention equipment to prevent uncontrolled release of well fluids from the well-bore. Blowout prevention is approached from four aspects: proper equipment, proper mud weight, proper training, and experienced supervision. Equipment currently being recommended are ram-type preventers with blind and pipe rams and bag-type preventers. Also essential to blowout prevention is proper cementing of intermediate strings of casing and the use of appropriate mud weights to balance reservoir pressure so that drilling will be under controlled conditions. For example, a mud weight that is too light may speed drilling, but could be inadequate to suppress a sudden gas entry.

All employees are and will continue to be instructed in the proper procedure for closing and opening blowout preventers (BOP's) which will be hydraulically operated. Safety is stressed in all aspects of this type of operation. The operator has an on-the-job training program using video tapes and projectors pertaining to safety, BOP's and maintenance, etc. (True Drilling Company has been awarded the International Association of Drilling Contractors Safety Commendation Award for seven consecutive years.)

Proper training of crews on how to recognize the symptoms of impending blowout conditions and how to correct these conditions is of utmost importance. An alert, experienced crew can handle all blowout conditions as part of their normal duties. If this is done, conditions should return to normal in a short time. The rig supervisor or pusher is responsible for training the crew and insuring that safe practices are followed. The pusher also makes sure that all equipment is properly maintained so that it will do its job when an emergency arises.

Since high wellhead pressures have been reported on geothermal wells in the Kilauea east rift zone, all wellheads, valves,and pipelines will be designed to withstand at least 2000 psi. Because of the extreme heat and gas content of the well fluids, most equipment must be derated below their name plate value. It is intended that 2000 psi or higher rated equipment will be used to provide an acceptable margin of safety.

In geothermal drilling, particularly while using air, drill pipe will wear quite heavily. Thus, frequent inspections of each length of drill pipe are conducted to detect stress cracking, corrosion, and general wear and tear. All tool joints are beefed up to provide a heavier wall to guard against erosion due to abrasion from the well-bore cuttings. A magnetic particle inspection unit will be available on site for conducting periodic pipe inspections. In addition to drill pipe inspections, all casing is inspected twice, once at the supply source and once on site before being used. These inspections are essential to prevent defective pieces of pipe being installed and creating a potential source of leaks.

Potential Hazards for Specified Events. The possible events, should they occur, that could create potential hazards to the health and safety of project personnel and other personnel within or near project activities are described below together with the actions that will be taken or planned in order to prevent or reduce the likelihood of such events occurring, or should they occur or not be preventable, to reduce the effects of the event on the health and safety of personnel that would be exposed to the event.

1) Volcanic Eruptions. Such events occurring without warning (which is very unlikely) at, within or immediately adjacent to project activity sites could cause serious injury or loss of life to personnel should they be at the point of eruption. This potential hazard to personnel is reduced in direct proportion to the amount of time between a warning of impending volcanic activity and the event and the distance of the event from a project activity site. An eruption directly under or adjacent to a project site could also rupture or destroy pipelines between well heads and power plants causing venting directly to the atmosphere of geothermal fluid if the volcanic activity also damaged the well head assembly and automatic well shut-off

system. If there were faulting associated with the eruption which intersected a well bore, there could also be a rupture of the well bore. If the rupture were near the surface and didn't seal itself off, it is possible there could be unabated venting to the atmosphere until an off-set well could be drilled. Eruptions not directly under or adjacent to a project site activity, even without warning, would pose far less hazard to personnel in the area.

Preventive or Mitigating Actions.

a) Establish and maintain continuous communications with the Hawaii Volcanoes Observatory to assure receipt of early warning of or impending eruption in the Kilauea East Rift Zone.

b) Instruct personnel on procedures to follow on receipt of a warning of an impending eruption and on actions to take in the event of an eruption within or adjacent to a project activity site including designation of evacuation or escape routes and industry procedures on protecting and securing the well head in the face of a threatening lava flow when it is feasible to do so.

c) Conduct an engineering analysis of each prospective drilling site and power plant site to be occupied, recognizing the potential of future eruptions at any point along the Kilauea East Rift Zone. When possible, sites will be selected to minimize the potential hazard of lava flows emanating uphill of project activity. In addition, the use of facility protection barriers, available high ground, and construction of facility platforms will reduce the hazards due to lava flowing into a project site.

2) Earthquakes and Sudden Ground Movement Due to Faulting. Earthquakes associated with volcanic activity in Hawaii are of small magnitude and have caused little damage. Tectonic earthquakes are larger in magnitude and occur

along or near major fault lines. The largest earthquake of record in Hawaii occurred southwest of Kalapana in 1975 and registered a magnitude of 7.2. Sudden subsidence may occur as a result of volcanic or tectonic earthquake, collapsing lava tubes and pit craters, or from subsurface intrusions. Such subsidence could, under some conditions, cause damage to project facilities including the possible rupture of a well bore if a sub-surface fault intersected the well bore. The result of the event could be a casing leak or perhaps venting to the atmosphere of the well flow if the well didn't seal itself off, in which case the venting would continue until an off-set well could be drilled to intersect the well below the rupture point.

Surface faulting and subsidence could rupture steam pipelines, again causing temporary venting of the well flow into the atmosphere if the faulting or eruptive activity caused the well head automatic shut-off system to malfunction.

Mitigating Measures. Analysis of past eruptions, often accompanied by cracking or subsidence near the vent area indicates there are areas in the rift zone where the potential for eruption is less than other areas. Siting of project facilities in such areas when possible can reduce the chances of eruptions and subsidence occurring at project sites so located. Siting of facilities outside the center of the rift zone when possible can significantly reduce the potential hazards of volcanic eruptions and accompanying subsidence and faulting. More predictable, the incorporation of design criteria into primary facilities and systems whose failure under such conditions could result in a health hazard, injury or loss of life will reduce the potential hazards of subsidence and earthquake activity in an active volcanic rift zone.

3) The Potential for Personnel to be Exposed to High Temperature Geothermal Fluids or Steam Under High Pressure. This potential hazard is increased in areas where personnel are working around pipelines, well heads, and tanks where space is restricted so as to prevent rapid movement or escape in the event of a rupture.

Mitigation Measures. Personnel working in such spaces will be required to wear protective clothing and masks. Back-up personnel will be present in a position adjacent to the restricted space while personnel are occupying such spaces in the performance of their duties.

4) Exposure to Chemicals Used in the Pollutant Abatement Systems. Personnel will be handling and mixing chemicals used in pollutant abatement systems and could be subject to overexposure that could cause injury or a health problem. Only experienced personnel will be utilized in this operation.

Mitigating Measures. Personnel will be instructed on the nature and hazards of each chemical being used, the methods of proper handling, storage and mixing of the chemicals and emergency procedures in the event of accident or over-exposure. Emergency water sources will be located near the chemical storage and mixing area. Special articles of protective clothing appropriate for the chemicals used will be available and required to be worn for handling or mixing specified chemicals. Appropriate fire suppression equipment will be positioned at the chemical storage container.

5) Possible Exposure to High (unsafe) Levels of Hydrogen Sulfide (H_2S). The geothermal resources in Hawaii that have been discovered and analyzed indicate the presence of H_2S at concentration levels in the range of 900 - 1300 ppm. While these concentrations are rapidly diluted on mixing with air

and/or as a result of the application of H_2S abatement procedures, an H_2S environment can be hazardous to personnel at or near the emission point unless adequate safety precautions are taken. During drilling operations, H_2S present in the geothermal resource would be emitted through the blooie line while drilling with air (after the reservoir is intersected), during venting of the well and during testing. H_2S emissions would be abated during drilling and testing, but unabated during well venting. Unabated emissions could also occur as a result of a blow-out of the well bore. Lower concentrations of H_2S gas have a sweet taste and the odor of rotten eggs and can be detected. Higher concentrations of H_2S (100 ppm) can impair the sense of smell in 2 - 15 minutes. Direct, continuous exposure to still higher concentration levels (500 ppm) over a period of 30 minutes to one (1) hour could cause lung paralysis and death.

Mitigating Measures. Project personnel are instructed at regularly conducted safety meetings on the hazards of H_2S as well as the proper procedures to be used during drilling, well completion and well testing which are designed to prevent uncontrolled emissions from the well bore. They are also instructed on how to use H_2S detection and air breathing equipment. Respiratory protection equipment is always available on site to be used by project personnel and authorized visitors as may be required. (See Emergency Plan, Appendix "F", for H_2S emergency procedures).

6) Exposure to Excessive Noise Levels. Project personnel will be exposed to continuous noise levels in the range of 60-80 decibles and impact noises exceeding that level and occasional noise levels of up to 120 decibles when venting a well.

Mitigating Measures. Project personnel will be required to have available and wear sound protection devices when in project areas generating maximum noise levels. A noise monitoring/recording instrument will be maintained at the drilling site.

7) Well Blowouts. A well blowout could occur below surface or at the well head. A blowout would result in the full or partial free flow of the high temperature, high pressure geothermal resource from the reservoir until it could be secured. Such an event could cause injury, or a health hazard, or create a nusiance if project personnel or nearby residents were exposed to excessive or nusiance levels of H_2S. A blowout due to a well bore rupture below the surface or at the well head could take several days or longer to secure, the longer time depending on the depth of the rupture which would have to be reached by off-set drilling.

Very few geothermal wells have failed in the world-wide industry. Some of the few that have occurred were the result of improper well siting in areas susceptible to landslides; setting surface casing at a depth that is too shallow; cementing the surface casing in incompetent rock formations; or, due to errors in planning or executing the drilling medium (fluid) program.

Mitigating Measures. Continually improving industry standards are being applied by operators to further reduce the chances of a well blowout. A well trained crew and reliable equipment are the most important elements of a blowout prevention program and these two key elements will be used for this project. (See Application for Permit to Drill, submitted concurrently to DLNR)

3. Drainage. Surface alterations to accommodate project operations will be designed to assure that normal area drainage patterns are not disturbed.

4. Signs. "No-Trespassing", hazardous warning and safety signs will be posted at applicable sites in the project area.

5. <u>Lighting Provisions</u>. Lighting for night operations will be designed and arranged to assure that such operations can be performed safely and efficiently. Bright light requirements can generally be directed or sheltered to limit any impacts outside of the project area. Because of the isolation of the project area, it is unlikely that lights will disturb any residential areas. Proper hazard lights will be installed on the top of the drill rig for aircraft that may overfly the project site.

6. <u>Changes in Landscape</u>. The landscape will be altered in portions of the project area where clearing of the forest is required for drilling sites, roads and power plant sites. Land surface requirements for project operations are described in the Revised Environmental Impact statement and the supplemental EIS for this project. Metes and bounds description of all areas to be cleared will be submitted to DLNR prior to conducting any clearing operations.

Air Quality and Meteorological Monitoring Program

Geothermal Development Activities

(Exploration Phase)

Kilauea Middle East Rift Zone

Estate of James Campbell Property TMK 1-2-10:3

True/Mid-Pacific Geothermal Venture

January, 1989

Appendix B
Letter to DLNR
DATED:__________

SUMMARY

This document presents a basic plan for an air quality and meteorological monitoring program to support the incremental exploration and development of the Kilauea Middle East Rift Zone Geothermal Resource Subzone (GRS), Puna District, Island of Hawaii. The Air Quality and Meteorological Monitoring Plan is submitted separately for approval to the Director of the Hawaii Department of Health (DoH) who has the State's responsibility for implementing EPA air quality regulations in Hawaii

The plan addresses primarily the monitoring to be accomplished during the initial exploration phase of the project. After a resource discovery, and upon making a decision to proceed into the development phase in a specific area of the project site, any required changes and/or additions to the monitoring plan will be submitted to the Director, DoH for approval and to the Director, Department of Land and Natural Resources (DLNR) with the submission for approval of the development plan for a specified level of development.

The major components of the program for the exploration phase are:

1. Design and implement a meteorological monitoring program to develop on-site data bases and to characterize drainage winds and potential stagnation zones in the project area as a basis for determining maximum impact areas for project emissions.

2. Conduct air quality and meteorological monitoring in areas of maximum estimated impacts for well drilling, venting and testing to capture the potential maximum impacts of these intermittent sources.

The monitoring program is consistent with the guidelines and requirements of the U. S. Environmental Protection Agency and will provide the information necessary to determine compliance of all phases of the project with the applicable ambient air quality standards.

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1. Introduction

This document presents a plan for an air quality and meteorological monitoring program to support the exploration phase of the incremental exploration and development of geothermal resources in the Kilauea Middle East Rift Zone Geothermal Resource Subzone (GRS), Puna District, Island of Hawaii.

The Board of Land and Natural Resources (BLNR) approved, in a Decision and Order issued on April 11, 1986 a long-range plan for the exploration and development of geothermal resources in the Kilauea Middle East Rift Zone GRS. This long-range plan provides for the development of 100 megawatts (MW) of electrical generation capacity to serve first the needs of the Island of Hawaii and secondly for export to Oahu via a deepwater transmission cable. As provided in the Decision and Order, the initial phase of the project will be the exploration phase during which limited drilling and testing of up to 12 exploratory wells will occur over a period of approximately 2 years. The exploration phase will provide preliminary data on the presence, location and characteristics of geothermal resources in the project area. The monitoring proposed for this initial increment of exploration will measure the air quality in the area of maximum estimated impacts due to emissions from drilling, venting and flow-testing of the exploratory wells.

As shown in the following sections, the monitoring program will follow the guidelines of the U. S. Environmental Protection Agency where appropriate and will provide the information necessary to demonstrate compliance with the applicable ambient air quality standards for the project activities described. The monitoring program will be updated and modified as appropriate in parallel with project development activities.

2. Air Quality and Meteorological Monitoring Guidelines

The Board of Land and Natural Resources Decision and Order (D&O) of April 11, 1986 requires that an Air Quality Monitoring Program and Meteorological Monitoring Program be implemented coincident with the start of drilling in the Kilauea Middle East Rift Zone Geothermal Resource Subzone (GRS). The Decision & Order specifies monitoring requirements and monitoring sites for the full 100 megawatt project and states that the Air Quality Monitoring Program will follow, where appropriate, U. S. EPA protocols and guidelines for monitoring and quality assurance documentation. The D&O further requires that the developer meet all Federal, State and County air quality standards. Finally, the D&O provides that the air quality program may be modified as deemed necessary by DLNR based on information derived in the initial phase or phases of the project in order to address activities to be undertaken subsequent to such initial phases.

The Director of the Hawaii Department of Health has the responsibility to implement and enforce the regulations for the EPA air quality programs in Hawaii, including the monitoring requirements. Chapters 59 (Ambient Air Quality Standards) and 60 (Air Pollution Control) of Title 11 of the Hawaii Administrative Rules prescribe the air quality standards and rules for stationary sources of air pollutant emissions in the state. Subchapter 3 of Chapter 60, Hawaii Administrative Rules, pertaining to stationary emission sources, provides the basis for the air quality and meteorological monitoring programs described herein. Subchapter 4 pertains to major stationery sources which, subject to additional criteria, may require an EPA PSD review concurrent with the application for Authority to Construct or Modify such an emission source.

Geothermal wells do not meet the EPA criteria of major permanent sources of emissions. Emissions from wells prior to being produced or "operated" occur only during a portion of the drilling and during venting and testing operations and only if the well encounters a geothermal resource. After testing is completed, the well is shut down until it is connected to a power plant as a supply well. Any potential emissions from the well when "operated" will be controlled at the power plant in accordance with the requirements of the air quality permits for the power plant. Thus, the emissions from well drilling, venting and testing and during operation as part of an operating power plant are not large enough to constitute a major source and, therefore, are not subject to EPA PSD review requirements.

It is possible that a very large permanent geothermal power plant would qualify as a major source of emissions subject to the EPA PSD review requirements. The latest edition of the EPA monitoring guidelines (EPA, 1987) provides very detailed information on 1) the monitoring requirements during the preconstruction and post-construction phases of operations and 2) the criteria for determining the location and number of monitoring stations appropriate for a new, major emission source.

Under PSD review procedures, preconstruction monitoring for a major new source is required in order to establish baseline (existing) air quality levels and meteorological conditions at the site of a new or modified emission source. The estimated impacts of the new or modified permanent source would be added to the baseline levels and the totals would be compared to the applicable ambient air quality standards to assure that the emission control systems in the new or modified source are adequate to maintain national and state ambient air quality standards. Baseline air quality in the Kilauea Middle East Rift Zone GRS has been thoroughly characterized in previous studies and the results of these studies, including air dispersion models to estimate potential impacts of project activities are summarized in the EIS for the project. A summary report of prior air quality and meteorological monitoring for the Kilauea east rift zone, which includes the project site for which this plan is designed, was prepared for the State (DPED, dated July 31, 1985). An executive summary of this report is appended as Attachment 1.

Post-construction monitoring for a new or modified permanent, major source may be required under PSD regulations to demonstrate that the emissions from this source do not cause or contribute to a violation of any applicable ambient air quality standards. In order to demonstrate compliance, the post-construction monitoring must be done at the location of maximum total impacts. "Ambient air" is defined in federal regulations (40CFR50.1(e)) as that portion of the atmosphere external to buildings, to where the general public has access. If the maximum modeled impacts are within an area excluded from ambient air (i.e., within the property boundary of a project), the monitor should be located downwind of the emission source at or near the property boundary.

Selecting the correct location for a monitoring station for an area with multiple permanent emission points as may be applicable for this project in the future, requires careful analysis of the meteorological conditions in that area in relation to the characteristics and design and location of the emission sources and pollutants being emitted. However, for the proposed initial exploration phase, there are no other sources present in the project area except for volcanic emissions, and these impacts have been characterized in the baseline air quality studies.

During the initial exploration phase, the proposed project is a very limited operation with respect to creating a permanent new source. There will be only one temporary source emitting at any one time during drilling and testing of wells. There will be only one well venting (i.e., emitting at an uncontrolled level) at any given time and then only for a maximum of eight hours. After venting, each well is flow tested for thirty to forty-five days using appropriate pollutant and noise abatement systems. As subsequent exploratory wells are drilled and the geothermal resource is encountered, the testing period for these subsequent wells will be shorter and shorter.

The following sections describe a monitoring program that is consistent with EPA protocols and guidelines and the nature of the incremental geothermal exploration and development activities that will occur in the project area.

3. Overview of Monitoring Program

A twofold monitoring approach will be taken in this program. During the exploration phase of the project, a continuous meteorological monitoring station will be located at Drilling Site A1 (See Figure 1). This will be supplemented by air quality and meteorological monitoring downwind of a drill site using a mobile monitoring van. When a decision is made to construct a permanent emission source (i.e., a power plant) for the production phase of the project, one or more permanent post-construction air quality monitoring stations will be established, as required, at the maximum impact area(s) to confirm that project emissions from the new permanent source are in compliance with National and State standards.

During the exploration phase, the mobile monitoring van will be located as close as possible to the maximum estimated impact area for each of the drilling sites shown in Figure 1. The air quality monitoring systems will be operated when emissions from drilling occur. In addition, passive H2S monitors will be operated at a radius of approximately three thousand feet in the primary downwind directions from each drill site. Any potentially significant pollution episodes during drilling and testing would be detected by the operation of the mobile monitoring van and the passive H2S monitors.

Standard U.S. EPA quality assurance documentation will be provided for the monitoring program as appropriate. Quarterly reports will be submitted so that the status of the air quality can be regularly reviewed by regulatory agencies.

4. Meteorological Monitoring

The discussion of meteorology for the project area as presented in the project EIS identified possible stagnation zones due to night-time formation of small scale fronts between drainage winds and trade winds as a consideration in estimating potential air quality impacts. The project EIS also summarized the results of relevant studies on the meteorology for the area including data from monitoring at two downwind sites near the property boundary of the project site. The descriptions of meteorology in the project site were based on these data and on extrapolations from meteorological data along the Kilauea east rift zone and regional stations.

The initial, continuous meteorological monitoring station will be installed at the first drill site on a standard 10 meter meteorological monitoring tower in order to obtain site-specific meteorological data. These data will be used throughout the exploration phase to identify maximum impact areas of emissions from drilling operations. Due to the interplay between trade winds, local drainage winds, and the land-sea breeze phenomenon, the point of maximum impact cannot be accurately estimated without site specific meteorological measurements. The tower will be instrumented at the 10 m level to obtain horizontal wind speed and direction, vertical wind speed and temperature. If a decision is made to proceed into a development phase, the cumulative data will be evaluated to determine whether the initial continuous monitoring station should be relocated in relationship to the planned power plant site, and to determine whether additional steps need to be taken to obtain more data on the extent and effects of drainage winds in the planned area of development; i.e., the use of a tethersonde to develop vertical profiles of wind speed, wind direction and temperature. Since there will be a time lapse of 16-20 months between the decision for the first increment of development and the initiation of power plant operations, there would be more than adequate time to complete this additional meteorological monitoring.

The meteorological monitoring for the exploration phase will be conducted at Drilling Site A1 (see Figure 1) since that area will be the base of operations for at least the first phase of exploration. The project area is currently undeveloped and there are no access roads, thus, the first access roads will be into the area around Drilling Site A1.

The monitoring system consists of Weather measure Model W203 and W204 sensors, a Campbell Scientific multilogger model CR121 and a 10 meter tower. A back-up chart recorder will be added to the system.

Radon monitoring will also be done as part of the continuous meteorological monitoring at the drill site. One track-etch radon monitor will be placed in a rain-shield housing at DSA1. The track-etch technique is a passive method. The three month sample exposure produced excellent results during the two and one-half years of baseline monitoring along the Kilauea East Rift and will be used in this monitoring program. The radon monitors which will be used are manufactured by Terradex Corporation and have been routinely used worldwide.

Water catchment (rainfall) samples will be collected from three downwind sites in neighboring residential communities on a quarterly basis. Acid-cleaned polyethylene collection systems were used during the baseline monitoring and will be used in this monitoring program. The pH of the samples will be measured with a portable pH meter promptly after collection. Table 1 lists the anions which will be measured by the IC technique.

5. Air Quality Monitoring

The continuous meteorological monitoring at drill site A-1 will be supplemented with air quality and meteorological monitoring in the areas of maximum estimated impacts for well drilling, testing and venting using the mobile monitoring van. Because of the proximity of the first drill site to a residential property boundary (1.9 miles) and based on existing meteorological data indicating the possibility of prevailing project site drainage winds in the direction of that boundary, the mobile monitoring van will be located initially along the access road between the drill site and the property boundary. As the on-site meteorological data base is expanded, it would be used to refine the analyses used to identify areas of maximum impact due to well drilling and to relocate the mobile van as required. To be consistent with the definition of "ambient air", the monitoring van would always be located in a prevailing downwind-of-source direction in the area of maximum impact at or beyond the property boundary.

The mobile monitoring station will monitor air quality and meteorological conditions for a minimum of one week before emissions commence from the well being drilled and continue during drilling, venting and testing. These monitoring sites will probably not have power available and a propane generator will be used. Propane will be used as a fuel rather than diesel or gasoline, so that generator exhaust will not impact the monitoring instrumentation.

The same basic approach used for air quality monitoring surveys conducted around Kahauale'a and the Puna Forest Reserve will be used in the program described here. For those parameters monitored, the same or equivalent instrumentation and analytical procedures will be used. The environmental parameters which will be measured with the mobile monitoring van are:

> Continuous ambient SO_2 concentrations. Hourly, and twenty-four hour averages will be tabulated and reported.

> Continuous ambient H_2S concentrations. Hourly and twenty-four hour averages will be tabulated and reported.

Total Suspended Particulate (TSP) and PM10 concentrations will be measured for twenty-four hour periods with high volume samplers. One sample will be collected every sixth day. This is a standard procedure used to insure that mean values calculated from the daily values are not biased (e.g., week days versus weekend days).

Wind speed and direction will be measured continuously. Hourly and twenty four hour averages will be tabulated and reported.

Continuous precipitation measurements will be made. Hourly and twenty-four hour totals will be tabulated and reported.

Gaseous mercury concentrations will be measured. One twenty-four hour sample will be collected simultaneously with the particulate samples every sixth day.

Sulfur dioxide and hydrogen sulfide measurements will be made with Meloy Laboratories (Columbia Scientific) or Thermo Electron Corporation sulfur analyzers or equivalent. The instrument used will be U.S. EPA-approved for ambient SO_2 monitoring which can be utilized with ancillary components for H_2S monitoring as well. These instruments provide a continuous record of atmospheric SO_2 and H_2S concentrations when interfaced with a data logger or chart recorder. Calibration will be performed with a VICI Metronics permeation device or equivalent. Calibrations will be performed on any day the monitoring van is moved to a new site and weekly during the monitoring period.

Particulate monitoring will be conducted with General Metal Works or Sierra (Andersen Samplers, Inc.) or equivalent high-volume samplers. The high-volume samplers are standard particulate monitoring instruments and have been used in numerous U.S. EPA monitoring programs. The samplers will be calibrated on a quarterly basis with commercially available orifice calibrators. Glass fiber filter media will be used with the high-volume sampler. The mass of particulate material will be determined by weighing before and after sample collection. An analytical balance will be used with the high-volume glass fiber filters. Special numbered field transport containers will be used.

Continuous wind speed and direction measurements will be made at the monitoring van with a recording wind speed/direction sensor system. A data logger and a back-up pressure sensitive recorder will be used to record the wind speed and direction data. The instruments proposed to be used are manufactured by Qualimetrics, Inc. or an equivalent quality manufacturer and consist of a 3-cup anemometer, an air foil vane, and a strip chart recorder. A folding seven meter tower is affixed to the monitoring van for the wind speed and direction sensors.

Continuous rainfall records will be made at the monitoring van. A tipping bucket rain gage is attached to the roof of the monitoring van. The continuous rainfall measurements will be recorded with an interfaced seven-day event recorder. The instrument which will be used is manufactured by Qualimetrics, Inc.

Total mercury vapor (elemental, inorganic compounds, and organometallic) samples will be collected at the monitoring van. A twenty-four sample will be collected simultaneously with the particulate samples. Pyrex glass wool/nitric acid sampling tubes or an equivalent technique will be used to capture the atmospheric mercury. The uv spectrophotometric technique will be used for the sample analysis.

In addition to the mobile monitoring van located at the point of maximum estimated impact, eight VICI Metronics passive H2S monitors will be positioned at primary downwind directions at a distance of approximately 3,000 feet from the drill site. These passive monitors will be operated continuously while drilling activity is occurring. Week-long sampling periods will permit H2S detection limits of several ppbv to be obtained. By thus positioning the H2S passive monitors, average atmospheric H2S levels in all primary downwind directions from the drill site can be documented.

6. Ancillary Data

Several types of ancillary data will be compiled during the environmental monitoring program. These are:

A log of exploration and development activities will be maintained by appropriate personnel. A special note will be made of all events that have the potential to affect the level of project emissions (e.g., well venting, shut down of well). This will permit a correlation to be made between pollutant levels measured by the environmental monitoring instrumentation and specific exploration and development activities. Mitigation strategies can then be developed. This log will be included as an appendix in the environmental monitoring reports.

A record of volcanic activity will be maintained since volcanic activity can significantly impact air quality. The weekly reports of volcanic activity published by the USGS Hawaiian Volcano Observatory which span the monitoring period will be included as an appendix in the environmental monitoring reports.

Local rainfall data recorded as part of the National Weather Service network will be included as an appendix in the monitoring reports. Rainfall affects pollutant levels both directly (the scrub-out effect) and indirectly (pollen and spore production, and dust suppression). Relevant meteorological sites where rainfall records are currently kept include: Mountain View, Leilani Estates, Pahoa, and Kapoho Beach. Relevant rainfall measurements and daily wind direction observations have also been made by the National Park Service at Lae Apuki (near Kalapana) as part of their fire control program.

Continuous wind speed and direction measurements are made at the HGP-A power plant. This data will be referenced in the environmental monitoring reports when such data are relevant.

Numerous scientific investigations have been performed in the Kilauea East Rift area by scientists associated with the Hawaiian Volcano Observatory (USGS), the National Park Service Research Center, the Mauna Loa Observatory, the HGP-A power plant, and the University of Hawaii. Should environmentally relevant data, reports or publications become available during the monitoring program, they will be referenced and described in the monitoring reports.

7. Quality Assurance and EPA Monitoring Guidelines and Protocols

Quality assurance documentation will be prepared following U.S. EPA guidelines. It will contain applicable components from "Guidelines and Specifications for Preparing Quality Assurance Project Plans, 1980, U.S. EPA, MERL/QA-2, EPA" (Table 2), with detailed standard operating procedures (SOPS) for all sampling, monitoring, and analytical procedures. The SOPs will follow where appropriate, EPA monitoring guidelines and protocols. A quality assurance report will be included as part of each quarterly environmental monitoring document.

To the extent practical, U.S. EPA siting guidelines will be followed for criteria pollutant monitoring (40 CFR part 58 Appendix E), for meteorological monitoring (EPA-600/4-82-060 Volume 4) and for siting precipitation measurement systems (EPA-600/4-82-042a).

8. Data Reduction and Reporting

Quarterly reports will be prepared. Due to the length of time required for analyses and data reduction, the quarterly reports will lag the actual monitoring quarter by approximately two months. Tables 3 and 4 list the data that will be produced and included in the quarterly reports.

In addition to the environmental data that will be compiled in the reports, data interpretation and discussions will be presented. The quarterly reports will also contain: (1) a description and photo-documentation of the monitoring sites, (2) a quality assurance report and (3) ancillary data as discussed in Paragraph 7.

Table 1

Anions in Rainwater Samples Analyzed by Ion Chromatography

	Anion	Symbol
1.	Bromide	Br^-
2.	Chloride	Cl^-
3.	Fluoride	F^-
4.	Phosphate	PO_4^{2-}
5.	Nitrite	NO_2^-
6.	Nitrate	NO_3^-
7.	Sulfate	SO_4^{2-}
8.	Sulfite	SO_3^{2-}

Table 2

Quality Assurance Content Requirements*

1. Title Page
2. Table of Contents
3. Project Description
4. Project Organization & Responsibilities
5. QA Objectives for measurement data in terms of precision, accuracy, completeness, and comparability
6. Sampling Procedures
7. Sample Custody
8. Calibration Procedures
9. Analytical Procedures
10. Data Analysis, Validation, and Reporting
11. Internal Quality Control Checks
12. Performance and System Audits
13. Preventive Maintenance
14. Specific routine procedures to be used to assess data precision, accuracy, and completeness
15. Corrective Action
16. Quality Assurance Reports to Management

* from: Guidelines and Specifications for Preparing Quality Assurance Project Plans, 1980, U.S. EPA, MERL/QA-2

Table 3

Environmental Data Set - Mobile Monitoring Station

Parameter	Units	Data Points
SO2	ppbv	24 hour means 1 hour means
H2S	ppbv	24 hour means 1 hour means
Total Mercury Vapor	ng/m3	24 hour integrated a
TSP	ug/m3	24 hour integrated va
PM-10 Particles	ug/m3	24 hour integrated a
Wind Speed and Direction	MPH and compass points	1 hour means frequency distribut c tabulations
Precipitation	inches	24 hour totals 1 hour totals

Table 4

Environmental Data Set - Drilling Site A1 Monitoring Station

Parameter	Units	Data Points
Wind Speed and Direction	MPH and degrees	1 hour means frequency distribution tabulations
Precipitation	inches	1 hour means 24 hour means
Radon	pCi/1	Three month integrated values
Rainwater Chemistry	pH units and ppm	1 sample collected during active drilling uncertain sampling duration, 30 elements, 8 anions and pH

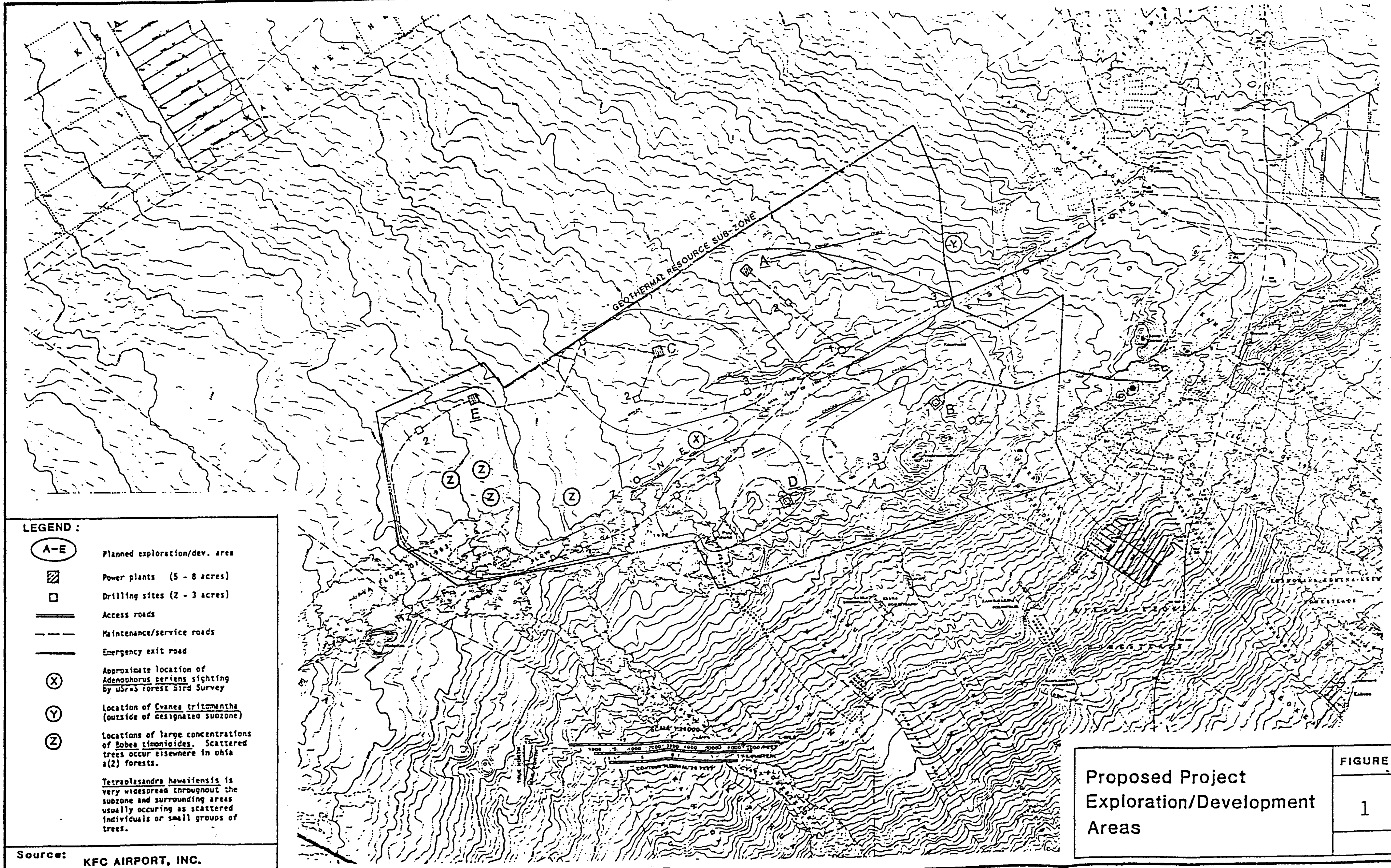


FIGURE 1

Proposed Project Exploration/Development Areas

Baseline Air Quality - Kilauea East Rift

Executive Summary

State of Hawaii

Department of Planning and Economic Development

James E. Houck, Ph.D., Principal Investigator
Gerald O. Lesperance, Program Administrator

September 13, 1985

ATTACHMENT 1
APPENDIX **B**

Baseline Air Quality - Kilauea East Rift

Introduction

The Kilauea East Rift on the Island of Hawaii is the technically most promising area within the State of Hawaii for future geothermal development. However, the East Rift area also contains large tracts of pristine forests, comprises a portion of the Hawaii Volcanoes National Park, and is surrounded by several small communities and a number of residential subdivisions. The Kilauea East Rift is volcanically very active and naturally emits air pollutants normally associated with industrial sources. Extensive baseline air quality monitoring has been conducted along the East Rift to quantify pre-development concentrations of environmentally hazardous pollutants so that any future change in their concentrations which may occur due to geothermal development can be assessed.

The report presented here is a summary of the results obtained from five recent baseline air quality studies. These are:

Environmental Baseline Survey, Kilauea East Rift
December, 1982, through December, 1983, study period
Hawaii Department of Planning and Economic Development (DPED)

Environmental Baseline Survey, Kilauea East Rift (Year Two)
1984 study period
Hawaii Department of Planning and Economic Development

Remote Environmental Baseline Monitoring, Hawaii Volcanoes National Park
1984 study period
National Park Service

Ambient Air Quality Monitoring Survey, Kahauale'a Geothermal Project
February, 1984, through February, 1985, study period
True/Mid-Pacific Geothermal Venture

Ambient Air Quality Monitoring Survey, Puna Forest Reserve
February and March, 1985, study period
True/Mid-Pacific Geothermal Venture

In addition to the data directly generated from these studies, a survey of data obtained from scientific research and other monitoring which have been done on the Island of Hawaii has been conducted. Relevant research performed by scientists associated with the University of Hawaii, the Hawaii Volcano

Observatory, the Mauna Loa Observatory; air quality monitoring conducted by the Hawaii Department of Health; and meteorological monitoring conducted by the National Park Service, Mid-Pacific Geothermal, Inc., the Thermal Power Company, and the National Weather Service have been incorporated into this report.

Six environmental pollutant categories were identified as being most important for study and their baseline levels were documented. These were: (1) atmospheric particles, (2) sulfur dioxide gas, (3) hydrogen sulfide gas, (4) rainwater chemistry, (5) atmospheric mercury, and (6) radon activity. Each of the pollutant categories are impacted by volcanism and/or can be impacted by future geothermal development. In addition to the quantification of specific ambient pollutant levels, wind speed, wind direction, and rainfall data were also studied, as meteorological conditions influence atmospheric pollutant levels.

The baseline study area comprises portions of the Ka'u and Puna Districts on the Island of Hawaii. Monitoring sites were selected along the East Rift from the summit of Kilauea Volcano to Cape Kumukahi; however, major emphasis was placed on the area from the summit to Highway 130. The area along the Pohoiki Road, where geothermal exploration and development have occurred, was purposely avoided to prevent the possible contamination of baseline samples by geothermal emissions. Relatively little sampling or monitoring was conducted at the extreme lower end of the Rift near Cape Kumukahi because that area is considered to have a low potential for future geothermal development.

The combined data base from the five environmental programs and from the meteorological monitoring that provides the basis for this executive summary is extensive. The data has been collected over a two and one-half year period and it includes: (1) approximately 17,000 hours of continuous sulfur dioxide (SO_2) gas measurements made at eleven locations, (2) one hundred and thirty-two integrated multi-day SO_2 gas samples collected at ten locations, (3) approximately 17,000 hours of continuous hydrogen sulfide (H_2S) gas measurements made at eleven locations, (4) one hundred and thirty-two integrated, multi-day H_2S gas samples collected at ten locations, (5) measurements from two hundred and seventy-five passive multi-day H_2S monitors placed at thirty-six locations, (6) atmospheric particulate concentrations determined from more than 750 samples collected at twenty-one locations, (7) analysis for thirty-four elements conducted on approximately 510 particulate samples, (8) additional elemental, anionic, and carbon analyses conducted on subsets of the particulate samples, (9) measurements from fifty-seven continuous quarterly and monthly radon-222 (Rn^{222}) monitors placed at eighteen locations, (10) pH, elemental, and anionic analyses (thirty-six elements and anions) conducted on fifty-one rainwater samples collected at fourteen locations, (11) additional trace elemental analysis conducted on a subset of the rainwater samples, (12) ten elemental mercury vapor samples collected at seven locations, (13) fifty-six total mercury vapor samples collected at nine locations, (14) approximately 510 particulate mercury analyses on samples collected at twenty-one locations, (15) fifty-three integrated multi-day chlorine (CL_2) gas samples collected at six locations, (16) over 60,000 hours of continuous wind speed and direction measurements made at fifteen locations, and (17) approximately 4,000 daily wind observations made at six locations.

The executive summary presented here contains a brief discussion of current pollutant levels and meteorological conditions characteristic of the East Rift area. The reader is referred to the complete summary report document submitted to DPED (July 31, 1985) for detailed data compilations and for a description of the monitoring networks and of the methods used in the environmental studies.

Atmospheric Particles

Monitoring for total suspended particles (TSP), respirable particles and inhalable particles was conducted along the Kilauea East Rift. In addition to atmospheric concentration levels the chemical composition of the particles was studied. Respirable (less than 2.5 microns in aerodynamic diameter) and inhalable (less than 15 microns in aerodynamic diameter) are considered more injurious to human health than larger particles since they reach the gas exchange areas and the air conducting pathways of the lungs, respectively, and are routinely monitored for that reason. Total suspended particles (TSP) are, as the name implies, all particles that are in the atmosphere. Sampling for TSP by utilizing high-volume samplers is a well-established regulatory procedure.

The atmospheric concentration of particulate material along the Kilauea East Rift has been found to be very low. The particulate concentrations characteristic of the East Rift are much lower than mainland values and U.S. Environmental Protection Agency (EPA) standards. While average TSP, inhalable particulate, and respirable particulate concentration levels are all lower than mainland averages, most dramatic are the exceptionally low respirable particulate concentration values. These are probably due to the absence of major anthropogenic combustion sources (viz, fossil fuel combustion) on the Island of Hawaii. Of interest to the fact that secondary particles formed from volcanic fume are primarily in the respirable size range and considerable volcanic activity did occur during the sampling period. During more typical periods of less active volcanism, respirable particulate levels would ostensibly be extremely low. Dust from geological sources suspended by traffic, agricultural activity, and wind, as well as volcanic tephra, are primarily greater than 2.5 microns in size and is greatest during periods of low rainfall. During the study years of 1983 and 1984, rainfall along the East Rift was lower than normal. At the Hawaii Volcanoes National Park (HVNP) headquarters there was a 40 inch and 13 inch departure from the mean annual rainfall level of 108 inches during 1983 and 1984, respectively. At the community of Pahoa there was a 48 inch and a 18 inch departure from the mean annual rainfall level of 151 inches during 1983 and 1984, respectively. As with the respirable particles; TSP and inhalable particulate levels characteristic of the East Rift area during more typical years are probably even lower than those measured during the baseline studies.

Elemental analyses were conducted on nearly all particulate samples. Several observations could be made by studying the elemental data: (1) the elemental values make up a relatively small percentrage of the overall particulate mass, (2) elements associated with sea salt (sodium, magnesium, sulfur, chlorine, potassium, and calcium), geological dust (aluminium, silicon, potassium, calcium, titanium, and iron), volcanic fume (sulfur and chlorine), smoke (carbon and potassium), and vegetative fragments (phosphorous) have the highest concentration levels, and (3) data for samples collected on the lower rift differ in a predictable way from data for samples collected on the upper rift.

Organic compounds, oxide oxygen, and water of hydration together comprise the largest portion of the particulate mass. Oxide oxygen and water of hydration cannot be easily quantified. Many of the elements measured contain oxygen in the compounds in which they occur, and large amounts of water can be expected to be associated with secondary volcanic fume particles and sea salt aerosol, especially in the high humidity environment typical of many locations on the rift. Organic carbon, elemental carbon, and carbonate carbon were measured in selected samples. The mass of organic compounds can be estimated from the mass of organic carbon by using a multiplication factor of 1.7 which takes into consideration nitrogen, oxygen, and hydrogen contained in organic compounds along with the carbon. It was found that organic compounds do comprise a significant fraction of the particulate mass. In some cases more than half the aerosal mass can be attributed to the organic compounds.

Chemical mass balance (CMB) source apportionment was conducted by mathematically comparing the average aerosol elemental data and the elemental data of particles originating from specific sources. The CMB modeling permitted the current sources of atmospheric particles to be estimated. Elemental data for road dust and volcanic tephra sources were directly obtained from samples collected on the Island of Hawaii. Other source data were obtained from reports of previous studies. While the impact of the particulate sources, as calculated by the CMB technique, vary from site to site, the differences between the sites are understandable in light of their geographical locations. Lower Rift sites have a high sea salt impact, a minor volcanic impact, and little or no smoke impact. Upper Rift sites have a low sea salt impact, a high volcanic impact, and a moderate smoke impact. Atmospheric particles in both areas have a moderate dust component, a large vegetative material component (pollen, spores, and vegetative fragments), and a very small vehicular exhaust component. (It should be emphasized that the use of the terms high and large are relative and that the total atmospheric particulate levels are all low.) By examining the CMB results of respirable, coarse (2.5-15 microns), and TSP data, it was obvious that sea salt, dust, and vegetative particles were primarily greater than 2.5 microns and impacted the inhalable and TSP levels much more than the respirable particulate levels. In contrast, volcanic fume, smoke, and vehicular exhaust were more predominant in the respirable size (less than 2.5 microns) category. This finding is consistent with the general understanding that particles entering the atmosphere by physical processes are larger in size than those formed from combustion and other high temperature sources.

In addition to CMB modeling, bivariant plots of elemental concentrations contained in ambient aerosols were helpful in determining the major sources of particles. Aluminium and silicon are key components in geological material. When dust from geological sources is a measurable component in atmospheric aerosols, there is a high degree of correlation between the two elements. A high degree of correlation was found between those two elements in particles collected at all monitoring sites along the Kilauea East Rift. Similarly, sulfur (as sulfate) and chlorine (as chloride) are key components in sea salt. At lower Rift sites where sea salt impact was greatest, there was a high degree of correlation between these two elements, particularly in the coarse fraction.

Particles originating from some sources are morphologically distinct and can be identified by microscopy. For example, photomicrographs of aerosol samples collected at the Royal Gardens Subdivision monitoring site (less than 50 meters from the coastline) clearly showed the predominant sea salt particles which were mostly 30 to 50 microns in diameter. Photomicrographs of aerosol samples collected at sites in areas of forest or agricultural activity frequently showed large vegetative bodies.

The impact of volcanism is episodic and overall annual means are not particularly illustrative in assessing the volcanic impact on air pollutant levels. During the nearly two and one half years of baseline monitoring, there were thirty phases of the current Kilauea eruption series and a rare eruption of Mauna Loa. By contrasting average values during periods of active volcanism and during periods of no volcanic activity, it was seen that volcanic activity did not significantly contribute to atmospheric particulate levels in the lower Rift area, but it did impact the upper Rift area. Particulate mass, particulate sulfate, and particulate selenium concentrations were most noticeably increased due to volcanic emissions.

Another and unexpected air quality impact of volcanic activity was measured during the first phase (January, 1983) of the current Kilauea eruption series. Apparently, the material emitted during this first phase was fractionated and was enriched in the more volatile chemical compounds; consequently, a dramatic atmospheric increase in transition and heavy metals contained in particles was noted during January, 1983. This phenomenon was seen during the DPED monitoring near the HVNP Visitors Center and by research scientists at the Mauna Loa Observatory. The high levels have not been observed during any subsequent eruption phases.

Sulfur Dioxide Gas

Sulfur dioxide (SO_2) gas was considered as a high priority pollutant for baseline monitoring since it occurs at relatively high concentrations in volcanic fume and would be produced at low levels in the atmosphere by the natural oxidation of hydrogen sulfide emitted from geothermal sources. It would also be produced directly by the geothermal industry at moderate levels if a H_2S incineration abatement system were used. Sulfur dioxide is associated with many industrial activities (viz, fossil fuel combustion and ore smelting) and is one of the principal mainland polluants responsible for acid rain and the formation of fine particles which cause visibility loss.

During the majority of the time during the baseline studies, atmospheric concentrations of SO_2 were below several tenths of a part per billion by volume (ppbv) at locations upwind (under prevailing trade and drainage winds) of the major volcanic vents of Halemaumau and Pu'u O. However, during periods of vigorous volcanic activity or during periods of unusual meteorological conditions, such as winds from the south, episodes of high concentrations, even exceeding the dynamic range of the instruments used, were recorded. Points downwind of the major volcanic vents do, of course, frequently have high atmospheric SO_2 concentrations.

Due to the short-term episodic nature of high SO_2 concentrations, the U.S. EPA annual average standard (30 ppbv) is not likely to be reached. The U.S. EPA twenty-four hour standard (140 ppbv), however, has been exceeded at upper rift sites. Similarly by comparing mainland urban averages, it could also be seen that annual average values typical of industrialized areas are not likely to be reached in the upper rift area (except directly downwind and adjacent to Halemaumau or Pu'u O), but maximum twenty-four hour values typical of urban areas can be exceeded due to active volcanism and/or unusual meteorological conditions.

Sulfur dioxide odor and taste thresholds are often exceeded near the Kilauea summit, as any traveler to the area knows. Plant damage due to SO_2, particularly to introduced species, does occur. During active volcanic periods and/or under poor atmospheric dispersion conditions, short-term health impacts can be expected in residential areas. Documented long-term chronic relationships are less clear, especially in light of the unusual exposure pattern to which residents of the area are subjected, i.e., short periods of high concentrations followed by long periods of trace ambient levels.

Hydrogen Sulfide Gas

Hydrogen sulfide (H_2S) gas was considered as a high priority pollutant for baseline monitoring since it is the principal pollutant associated with geothermal power plants. It is also a minor component of volcanic fume and is produced naturally by anaerobic respiration. Its atmospheric half-life before it is oxidized to SO_2 is approximately five hours. While H_2S is hazardous to human health and to the environment at high concentrations, at the low levels at which it is likely to be encountered due to geothermal development the major problem is nuisance odor. The human olfactory sensitivity to its "rotten-egg" odor is exceptional.

During the overwhelming majority of the time, the atmospheric concentration of H_2S was below several tenths of a ppbv at the baseline study sites. Very infrequently, concentrations in the 10-30 ppbv range were reached. As with SO_2, these high values were episodic, short-lasting in nature, and due to volcanic fume impact. The episodes measured at the HVNP Visitors Center were possibly due to the site's proximity to the Sulfur Banks, where an early exploratory geothermal well was drilled. Occasionally, H_2S concentrations in the several ppbv range may occur locally at middle and lower rift zone areas due to anaerobic respiration. Water-logged, organic-rich soils, such as occur in much of the Puna District, make ideal conditions for the production of H_2S by anaerobic respiration. Such naturally produced H_2S was measured at a monitoring site referred to as the Waikahekahe site. The Waikahekahe monitoring site was located on the large relatively recent pahoehoe flat that lies to the north of Pahoa. The flat is characterized by shallow soil, thick grass, and scattered, stunted ohia trees. After periods of heavy rain, the shallow soil becomes covered with water due to the poor drainage in the underlying pahoehoe lava.

Rainwater Chemistry

The chemical composition of rainwater is an important parameter to examine on the Kilauea East Rift for three primary reasons: (1) rain "scrubs" the atmosphere of pollutants and by doing so becomes contaminated with them,

(2) acid gases and mists emitted by volcanoes will produce "acid rain," the deleterious impact of which is a topical issue, and (3) many Rift residents use rainwater catchment as their source of drinking water. During the period from December, 1982, through March, 1985, over fifty rainwater samples were collected and analyzed.

Three major factors influence rainwater chemistry along the Rift: (1) all rainfall in Hawaii has a tendency to be slightly acidic due to the long range transport of pollutants from industrialized mainland areas, (2) volcanic emissions locally acidifies rain and impacts its chemical composition, and (3) sea salt aerosol makes rain less acidic due to its bicarbonate content and also impacts the chemical composition of the rain.

By contrasting the average chemical composition of rain collected at several sites, the impact of volcanic emissions and sea salt could be illustrated. A monitoring site near the Royal Gardens Subdivision was located less than fifty meters from the coastline and hence rain collected there was heavily impacted by sea salt. The major sea salt species (calcium, magnesium, potassium, sodium, strontium, chloride, and sulfate) were relatively higher in the rain collected there than in rain collected at any other site. A monitoring site on the Chain of Craters road was downwind of Pu'u O. The major chemical species associated with volcanic fume (fluoride, chloride, and sulfate) and volcanic tephra (aluminium, calcium, iron, manganese, potassium, and silicon) were apparent in the chemical composition of the rain collected there. In rain collected at sites which were at greater distance from the coastline and which were not heavily impacted by volcanic emissions, the concentrations of the aforementioned chemical species were lower.

The impact of sea salt is elevation-dependent on the Island of Hawaii. Using the average sodium concentration in rainwater samples collected for the baseline studies and in samples collected and analyzed in a previous scientific study, the decrease in the impact of sea salt with elevation could be graphically illustrated.

The impact due to volcanism is also elevation-dependent mainly because the major volcanic vents and fumaroles are above 2,000 feet. Using pH as an indicator of volcanic impact, the increase in volcanic impact at about that elevation could be seen.

The pH of the Kilauea East Rift rainwater falls between literature values for polluted and unpolluted rain and the rainwater is more acidic than typical river water and the drinking water criteria acceptable range. The concentrations of the major chemical species in the Kilauea East Rift rainwater, however, are all much lower than literature values for unpolluted coastal rain and are also well below average river water values. River water is, of course, the source of drinking water for much of the world's population. The concentrations of sulfate, of nitrate, and of race elements except cadmium, lead and selenium were demonstrated as being below drinking water criteria levels. Rainwater cadmium and lead values may be below the drinking water criteria levels, but the analytical technique used for their analysis in rainwater was not sensitive enough to document that fact. Selenium concentration, while measured in only five samples, was above the drinking water criteria value (0.01 ppm) in three of the samples (0.04-0.06 ppm). A possible secondary impact of the mild acidity characteristic of the Kilauea rainwater should be noted. Elevated concentrations of copper, lead, and zinc may appear in catchment drinking water if copper pipes, lead solder, or galvanized (zinc) pipes or roofing are used in the catchment system. This exposure risk would be greater in the upper portions of the Rift where the acidity of the rainwater is higher.

Mercury Vapor

The toxicity of mercury and the devastating health impact of acute and chronic industrial exposures have historically been very well documented. Numerous mercury vapor measurements have been made on the Kilauea East Rift. Reported total mercury vapor (elemental, organometallic, and halide) values typically range from several ng/m^3 to several hundred ng/m^3. Temporal, spatial, and analytical differences are probably responsible for the range in values. Two opposing factors control mercury vapor on the Rift. The unpolluted atmosphere above the open ocean (i.e., the tradewinds) have a very low mercury content (less than 1 ng/m^3). Volcanic fume, on the other hand, can contain hundreds to tens of thousands of ng/m^3 of mercury. The degree of volcanic activity, the location of a given sampling site with respect to vents and/or geological features, and the meteorological conditions during sample collection can all alter the observed atmospheric mercury concentration. It should also be emphasized that the measurement of any pollutant to the nanogram per cubic meter range should be viewed cautiously, and the values reported should be considered order of magnitude values at best. (One nanogram is 0.000000001 gram and there are 454 grams in a pound. Stated another way, 1 ng/m^3 is approximately one part in a trillion by weight.)

In addition to total mercury vapor, elemental vapor and total particulate mercury measurements have been made. The average elemental mercury vapor values ranged from 4 to 30 ng/m^3. The average particulate mercury vapor values were less than or equal to the average uncertainties associated with the measurement technique (several ng/m^3). During the Phase I eruption of Kilauea (January, 1983), measurable particulate mercury concentrations were, however, observed (4 ng/m^3 was the highest value).

By comparing the ambient mercury values with values characteristic of other locations, it could be seen that values measured on the East Rift, except for the summit of Kilauea, are more or less typical of continental sites and dramatically lower than occupational health standards. The values reported for the Kilauea summit are reasonable in comparison with the other volcanic values and are also lower than occupational health standards.

The concern over atmospheric mercury appears at times to be excessive and should be placed in its proper perspective by doing a simple calculation. Assuming a 200 ng/m^3 atmospheric concentration, a normal human lifetime of seventy years, a normal human inhalation rate of 20 m^3/day and assuming that all mercury in the air which is inhaled is absorbed, the amount of mercury "collected" by an individual over a lifetime can be easily calculated as being 0.1 grams. It should also be emphasized that mercury is ubiquitous and that there are many other current pathways of exposure other than air. For example, virtually all individuals within the United States have dental fillings which are essentially a mercury-silver analgam, many medications contain mercury (e.g., mercurochrome), and unfortunately so do many foods.

Radon Activity

Radon-222 is a radioactive gas naturally formed from the decay of radium contained in geological materials. Radon-222 has a 3.8 day half-life and decays via an energetic alpha particle. Two of its daughter products (Polonium-218 and Polonium-214) also have very short half-lives (3.0 minutes and 1.6 x 10^{-4} seconds, respectively) and also deay by energetic alpha particles. Due to the radioactivity of Radon-222 and its daughter products, and the fact that Radon-222 is a gas which can be inhaled, high Radon-222 concentrations are injurious to human health. As with atmospheric mercury, two opposing factors control the atmospheric radon content on the Kilauea East Rift. High radon emission rates are associated with volcanic areas. Conversely, air above the open oceans, such as constitutes the trade winds, has a very low radon activity (approximately 0.01 pCi/l).

A total of fifty-seven passive radon monitors were located at eighteen different sites along the Rift during the two and one-half years of baseline monitoring. Two sites had significantly higher average radon activities than the others: the Napau Crater Site and the Kahauale'a Proposed Drill Site. During the DPED baseline study, the Napau Crater Site routinely had the highest quarterly radon activity among the six sites. Conversely, the high average calculated for the Kahauale'a Proposed Drill Site is due to a single very high value (3.43 pCi/l) obtained when a monitor was placed over a fresh, still-hot lava flow to replace a monitor that was destroyed several weeks earlier by the flow. The values obtained with monitors before the flow and the value obtained with a monitor installed after the high-level monitoring period, show that radon activities during those periods at the site were more or less typical of the Rift area as a whole. The high value obtained with the monitor above the fresh lava flow apparently was either due to the fresh lava emanating radon at a high rate or due to the emanation rate of the soil beneath the flow increasing as a result of being heated by the flow. The routine higher values obtained at the Napau Crater Site are understandable in light of the fact that the site is directly on the Rift and that the monitoring period for the DPED baseline study was December, 1982, through December, 1983. The January 3, 1983, eruption was only several hundred meters uprift of the sampling site. During the sampling period, the eruption moved down the Rift past and in line with the Napau Crater Site with some spattering occurring as close as 100 meters to it. Consequently, the Napau monitors were exposed to vigorous volcanic degassing.

The lowest radon activity was measured at the Waikahekahe Site. This is consistent with the water saturated soil observed at the site. The emanation rate of radon from water saturated soil has been shown to be lower than that of drier soil since soil voids are filled with liquid rather than air under saturated conditions. Radon, a gas, diffuses faster through another gas than through a liquid.

The average radon activity levels ranged from 0.16 pCi/l to 1.14 pCi/l at the various monitoring locations on the Rift. If the Napau Site and the Drill Site are excluded, the range of values is from 0.16 pCi/l to 0.52 pCi/l. The latter range is more representative than the former of the range of values to which the residents of the Rift area are exposed, since few people live for long periods directly over eruption sites or lava flows. The range in Radon-222 values along the Rift is more or less typical of mainland outdoor exposure values and is below standard levels. The Kilauea outdoor levels are also lower than values typical of many North American and European homes. The build-up of indoor radon will not occur in typical Hawaiian homes, as it does in continental homes, due to the single-wall construction and high air exchange rates characteristic of most homes in Hawaii. The high build-up of radon in continental homes is principally due to low air exchange rates caused by intentional weatherization to conserve energy for heating and/or air conditioning, and due to simply keeping windows and doors closed during cold (or hot) weather. Most Hawaiian homes in the Puna and Ka'u Districts also have crawl spaces because of moisture and insect problems. Separation of homes from the soil by a crawl space was shown to markedly decrease the indoor radon activity in homes built in Florida above phosphate mining regions.

Other Air Pollutants

Three other air pollutants which merit discussion are: carbon monoxide (CO), nitrogen oxides (NO_x), and chlorine gas (Cl_2). Even though CO and NO_x are often major air contaminants in many airsheds, they were not considered as high priority pollutants for study on the Kilauea East Rift. They are primarily associated with industrial combustion sources, not geothermal activities. Their current atmospheric concentrations above the East Rift are unquestionably very low, although some CO is present in volcanic fume, some is produced by automobiles, and some is produced by industrial activity in the Hilo area. Three CO grab samples were collected on the Rift in 1983. The sampling technique used was not very sensitive, and the data simply illustrates that the atmospheric CO concentrations were below U.S. EPA Standards. No nitrous oxide gas measurements were made during the baseline studies; however, nitrate (NO_3) and nitrite (NO_2) concentrations were measured in selected particulate samples and in all rainwater samples. Nitrite was below the analytical detection limits in all particulate and rainwater samples. Nitrate, on the other hand, occurred at low, but measurable, concentrations in the particulate and rainwater samples.

Multi-day sampling was conducted for chlorine gas during the DPED and National Park Service baseline studies. Chlorine gas is not a pollutant normally studied in air quality programs; however, since Cl_2 gas can be used for hydrogen sulfide abatement in the geothermal industry and it is a very hazardous and environmentally damaging gas, baseline data for it was collected at six locations during 1983 and 1984. The concentrations measured on the Rift were very low and well below industrial exposure standards and biological impact levels.

Meteorology

Wind speed, wind direction, and rainfall patterns on the Kilauea East Rift were studied during the baseline programs. The obvious relationship between these parameters and atmospheric pollutant levels necessitates their inclusion into any discussion of air quality. Continous wind measurements have been made at fifteen locations in the Kilauea East Rift area for various time periods, and regular wind observations hve been made at another six relevant sites. Rain gages have long been maintained at a great number of locations on the Island of Hawaii by various organizations and individuals.

Wind direction and speed summaries were prepared illustrating average daily wind speed and directions made from continuous monitoring records and from single daily observations. The summaries based on single daily observations provide a somewhat biased picture of the average wind conditions as regular diurnal shifts have been found to occur.

The diurnal shifts in wind speed and direction are the result of the interactions of katabatic-anabatic flows (downslope-upslope mountain flows) and the land-sea breeze phenomenon with the prevailing trades (as they are deflected by the local topography). Due to these interactions, average nighttime wind speeds are lower than average daytime speeds, and wind directions tend to shift toward the west at night from the typical north to northeast daytime trade conditions. When average wind directions were examined for two hour increments, the diurnal shift was very apparent. The occurrence of winds from the north and northeast is at a maximum in the late afternoon and the occurrence of winds from the west and northwest is at a maximum in the early morning.

The environmental significance of the diurnal change in wind conditions is that there is not a single prevailing downwind point from any emission source, and moreover, the point of maximum impact for any given emission source (volcanic or anthropogenic) can be expected to shift 45^{o} to 90^{o} daily ostensibly everywhere in the Kilauea East Rift area. The lower nighttime wind speed coupled with the typical ground level nighttime temperature inversion caused by radiational cooling (a few degrees over several hundred feet), suggest that atmospheric dispersion will be poorer during the night.

It is clear from the summary data that prevailing winds on the Kilauea East Rift range from the west to the east over the "northern half" of the compass points depending on the exact location on the Rift. It, however, should not be forgotten that winds from the southerly direction do also occur a measurable fraction of the time. Unusual weather conditions, such as kona storms and tropical cyclones, can cause these southerly winds.

Rainfall levels impact air quality. The magnitude of the "scrub-out" effect, the suspension of dust, and the production of spores and pollen by plants are all directly or indirectly dependent on rainfall. Significant temporal and spatial rainfall variability both occur in the Rift area. As previously discussed, a drought occurred during portions of 1983, and rainfall levels during 1984 were below normal as well. Consequently, most pollutant levels measured during 1983 and 1984 were probably higher than levels that would be typical during wetter years if all else were equal. A high spatial variability in precipitation over short distances also occurs in the region due to orographic rainfall patterns. Average annual rainfall ranges from less than 19.7 inches to more than 196.9 inches in less than 35 kilometers.

Noise Monitoring Plan

Geothermal Development Activities

(Exploration Phase)

Kilauea Middle East Rift Zone

Estate of James Campbell Property TMK 1-2-10:3

True/Mid-Pacific Geothermal Venture

January, 1989

Appendix C
Letter to DLNR
DATED: _______

Noise Monitoring Program

Applicable Regulatory Decisions & Policies

The Land Board's Decision and Order of April 11th, 1986 requires that: (1) "The Noise Monitoring Plan shall include evaluation of predicted noise levels (by simulating actual sound levels) for selected sites in the residential areas near the proposed drilling and testing operations in the KMER/GRS prior to initiating exploratory well drilling", (2) that "the number and location of on-site and off-site monitor sites shall be subject to determination of DLNR", and (3) that "mobile stations may be used."

The D&O further prescribes noise guidelines that are extracted from the County of Hawaii noise guidelines which are applicable to this project "until such time as noise regulations are adopted by the State or County." Finally, the D&O states that the noise level monitoring and standards for project operations shall be applied at receptors located within nearby residental areas north, east and south of the project area, and that noise guidelines may be administratively adjusted by DLNR based on information derived in the initial phases of the project in order to address activities to be undertaken subsequent to the initial phase.

The County of Hawaii Noise guidelines state that"...as part of the overall analysis of the impacts of geothermal activities in Puna, a noise monitoring program will be implemented when the well drilling, testing, and production commence. This program should coordinate noise complaints with noise measurements, meteorological conditions and the type of operation which occurred at the well site. This data could then be used to determine if there is justification to invoke more stringent noise mitigative procedures and/or devices, to reduce or increase the allowable residential receptor noise level guidelines."

The County guidelines also provide that the noise level measurements should take place at the affected residential receptors that may be impacted by the geothermal operation.

<u>Nature and Characteristics of Noises Generated by Geothermal Project Operations</u>

The primary noises associated with the development and utilization of geothermal resources are created by drilling of wells (power generators, air compressors and escaping pressurized air, pumps and portable cranes) and power plant operations (steam and fluid flow through pipelines including steam line bleeding, and operation of the turbine/generator, cooling tower fans, pumps and transformers). There is a considerable body of knowledge and proven technical procedures within industry as to (1) the noise levels (including temporal) and the frequency spectra of sounds created by the use or operation of various motors and equipments and (2) the materials and devices that can be installed or used to reduce the noise levels emanating from those sources.

This knowledge on noise levels of operating equipment combined with the general knowledge of the sound propagation conditions (weather/terrain) in the project site area can be used to predict fairly accurately the levels of project operations noises at various distances from the project site except in those instances when meteorological phenomena can cause sound to focus temporarily and intermittently at random distances and directions. The approved Environmental Impact Statements for this project (Revised Environmental Impact Statement for the Kahauale'a Geothermal Project - June, 1982, and the Final Supplemental EIS to the Revised EIS for Kahauale'a Geothermal project - Feb, 1986) and the testimony at the various contested hearings presented extensive and detailed information on the forecasting of project noise levels at selected receptor distances under various generic types of weather conditions. These forecasts indicated that the noise level guidelines for the County of Hawaii could be attained during development activities (except for well venting) at the nearest property boundaries with appropriate sound attenuation methodologies and devices.

The noise levels of project operations that are measurable at a given receptor site depend on the strength of each noise source operating in the project site, the height of any source or sources operating above ground,the spatial relationship among all sources operating, and the sound propagation loss (or attenuation) that occurs along the sound transmission path between all project noise sources and the receptor. The rate of attenuation is directly affected by the distance, the weather and the characteristics of the terrain between source and receptor.

The orientation and positioning of project equipment in relation to each other (on and above the ground) will significantly affect project sound propagation and the "signature" at the receptor of total project noises for a particular operation at the drilling site. As an example, noise level measurements made in 1981 of geothermal drilling operations in Puna showed a distinct sounddirectivity pattern attributable to the combined additive effect of multiple noise sources represented by individual operating equipment items within the site. That is, noise from the drilling site did not radiate equally in all directions, but emanated substantially stronger in certain sectors due to the relative locations and simultaneous operation of multiple noise sources. (See Figure C-1). Therefore, short term measurements of an artificial or simulated sound source under the meteorological conditions that exist when the measurements are made are not likely to represent the actual noises of project equipment in their operating configurations and locations (with sound attenuation equipment installed) within a cleared drilling site. It is also improbable that the existing meteorological conditions during short term noise simulation testing would constitute representative adverse meteorological conditions for the project site.

Noise Monitoring During Drilling of Exploration Wells

The objective of noise monitoring is to determine whether noise levels emanating from project operating systems have been attenuated sufficiently so that the combined noise level of simultaneously operating equipment will meet prescribed noise level standards at nearest residential receptors under the widest possible range of meterological conditions. Therefore, monitoring must occur when all project systems are operating simultaneously in their normal mode with attenuation devices installed and when meterological conditions would enhance sound propagation in the direction of the nearest residential receptor.

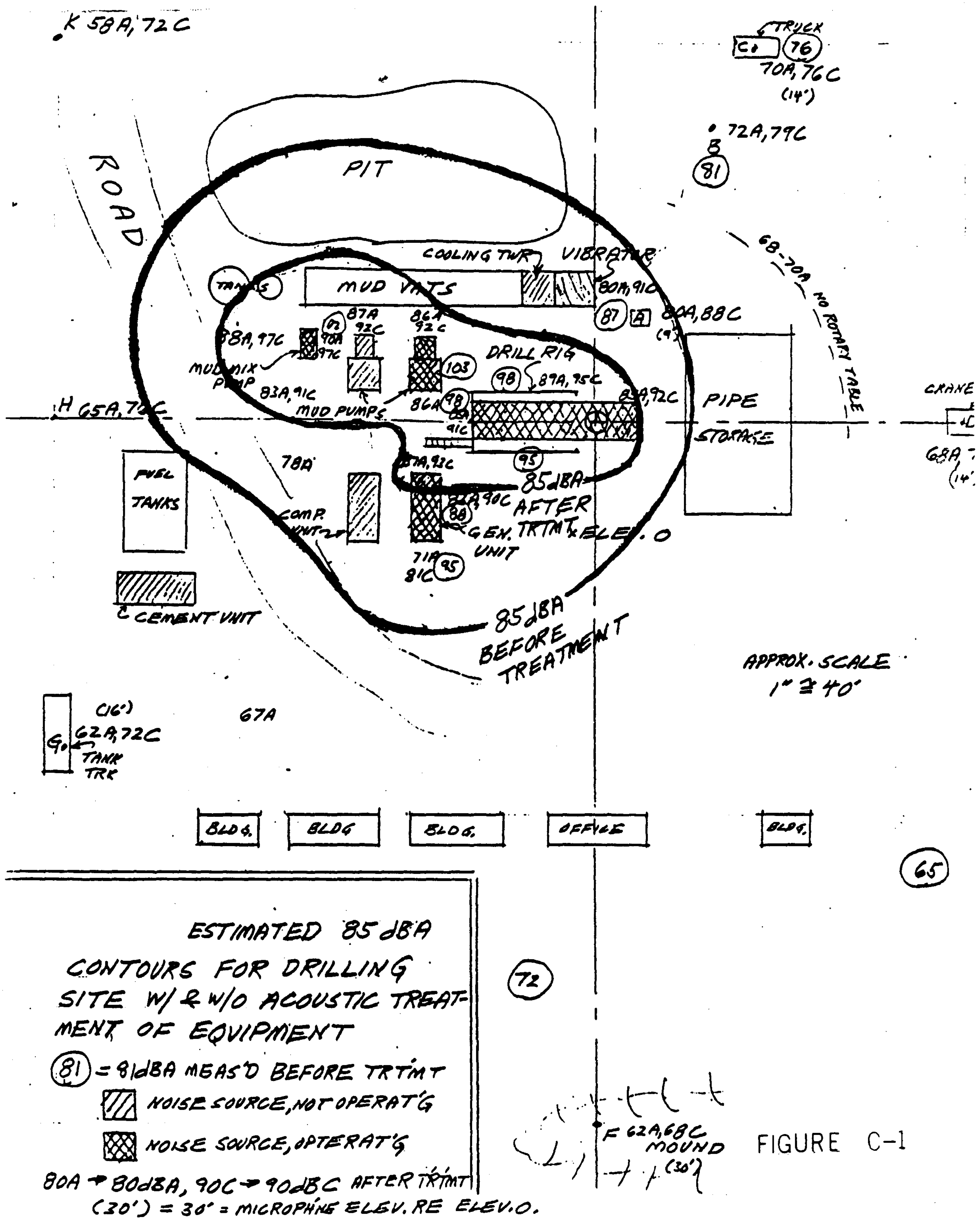

K 58A, 72C
TRUCK
C
76
70A, 76C
(14')
72A, 79C
B
81
PIT
ROAD
68-70A NO ROTARY TABLE
COOLING TWR
VIBRATOR
TANKS
MUD VATS
80A, 91C
87
A
80A, 88C
(9')
88A, 97C
87A
92C
86A
92C
90A
97C
MUD MIX PUMP
83A, 91C
MUD PUMPS
103
DRILL RIG
98
89A, 95C
83A, 92C
PIPE STORAGE
CRANE
H 65A, 72C
86A
91C
95
68A
(14')
FUEL TANKS
78A
87A, 92C
85dBA AFTER TRTMT
82A, 90C
88
COMP. UNIT
GEN. UNIT
ELEV. 0
71A
81C
95
C CEMENT UNIT
85dBA BEFORE TREATMENT
APPROX. SCALE
1" ≅ 40'
(16')
67A
G
62A, 72C
TANK TRK
BLDG.
BLDG
BLDG.
OFFICE
BLDG.
65
ESTIMATED 85 dBA CONTOURS FOR DRILLING SITE W/ & W/O ACOUSTIC TREATMENT OF EQUIPMENT
72
81 = 81dBA MEAS'D BEFORE TRTMT
NOISE SOURCE, NOT OPERAT'G
NOISE SOURCE, OPERAT'G
F 62A, 68C
MOUND
(30')
80A → 80dBA, 90C → 90dBC AFTER TRTMT
(30') = 30' = MICROPHONE ELEV. RE ELEV. O.

FIGURE C-1

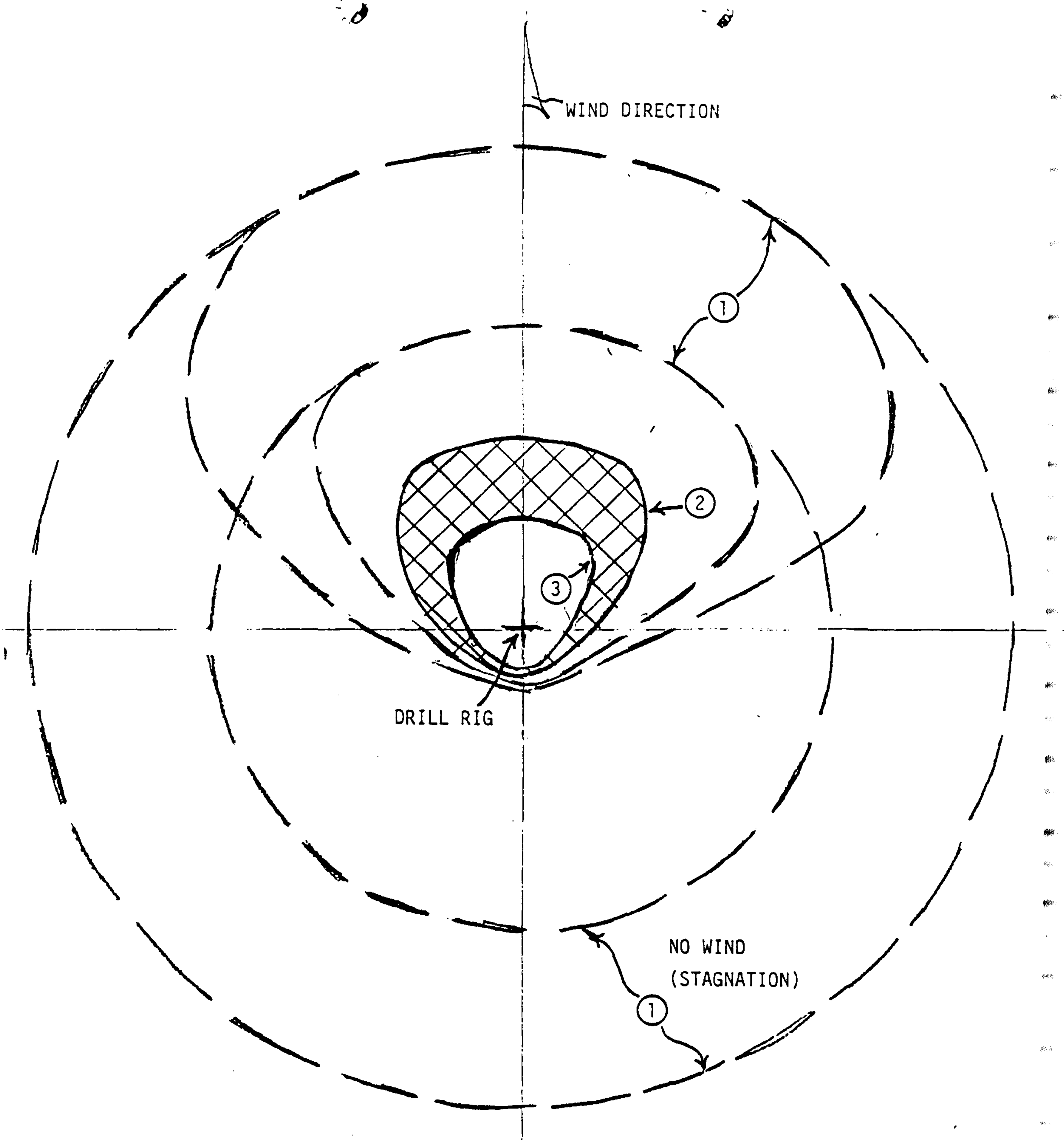
The initial prediction of noise levels of the drilling rig and associated equipment at boundary receptors is based on the characteristic operating noise level of each noise source at a distance of 100 feet and propagation calculations at various distances from the drilling site under various adverse meteorological conditions. These calculations provide the basis for determining whether additional attenuation devices/procedures will have to be applied to enable noise level standards to be maintained at the property boundary under adverse meterological conditions. This will enable each piece of equipment to nominally meet the county standard at the nearest receptor when it arrives at the project site. Additional permanent noise mitigation systems may be required in response to any unexpected pattern of unfavorable weather conditions that may be manifested in the project area over an extended period of time. In addition, total project noise levels emanating from a particular project site could exceed the noise standard at the property boundary due to unusual meterological short-term phenomena in which case temporary mitigation devices or measures may have to be applied, including the reorientation of operating equipment to adjust to the meterological condition.

The use of a noise simulation device to represent the noise level and frequencies of the drilling rig and associated equipment during actual operations and the monitoring of the simulated noise level at various residential receptors would not serve any useful purpose since the data obtained would not provide reliable, predictive information on which to apply or modify equipment noise mitigation systems and devices. Moreover, this type of test would not provide sound propagation data in the short term that is not now available or forcastable.

Industry technology on noise mitigation is well- established and the effectiveness of that technology has been clearly demonstrated with the drilling of the last geothermal exploration well by Thermal Power Company in the lower east rift zone, where the nearest downwind residence was approximately ½ mile from the drill site. There were no reported noise complaints during the drilling of that well. Similar results can be achieved during drilling in the Kilauea middle east rift zone, in the presence of high density forest (which attenuates sound) and where the nearest prevailing downwind residential property is at a distance of approximately 7 miles from the drill site A1, and the nearest residence to dominant night time winds, when they prevail, is 1.9 miles from the drill site.

The predicted noise levels at downwind receptors nearest the project site have been calculated on the basis of sound propagation models assuming (1) a base level of noise attenuation systems being applied to project equipments to limit the noise to a specific level at 100 feet and (2) the prevalence of various types of weather conditions that would enhance the transmission of sound. This data indicates that the noises associated with drilling operations (except for venting of the well bore) will be within the Hawaii County noise guidelines prescribed for the nearest residential receptor. See Figures C-2, C-3 and C-4, and Table C-1.

Based on the plan to initiate exploration drilling at drill site A1, which is approximately 10,000 ft., or 1.9 miles, from the nearest residences that could be downwind of the drilling site under certain meteorological conditions, it is proposed that sound monitoring for drilling the first well be conducted as



45 dBA NOISE LEVEL CONTOURS FOR DRILL RIG 82 dBA @ 100'.
SCALE: 1"=3,000'. SOUND PROPAGATION CONDITION IN ◯.

FIGURE C-2

TYPICAL dBA NOISE LEVELS AT 100' FROM SOURCES
FOR DRILLING & VENTING IN GEOTHERMAL OPERATIONS

Noise Source	Geysers, California Measurements	Lake County, California Regulations	Cobb Valley EIS Measurements	Cobb Valley EIS Recommended Regulations	Barnwell Rig Measurements Hawaii: Good Mufflers Some Silencing	Barnwell Rig Measurements Hawaii: Considerable Acoustic Treatment	True/Mid-Pacific Kahauale'a EIS: Table 5-2 (EPA Data)	True/Mid-Pacific Kahauale'a EIS: Appendix F	Hearing Testimony
Drill Rig			74 - 80	75	79	70	69 - 74	74 - 89	
Mud Pumps			85	75					
Air Compressors			95	75					
Steam Venting During Drilling		82							82
(a) minimal	77		103				103		
(b) w/ water injector #1			97				83		
(c) w/ water injector #2			77				73		
Rock Mufflers									
360,000 lbs/hr			90						
150,000 lbs/hr			76	75					
Average			80			80	77		80
Free Venting			122		121		112		None/122
Power Plant									
Cooling Tower			68						
Turbine Bldg			77 } 75				60 - 70		75
Transformer			72						

TABLE C-1

described below pending the collection and analysis of site specific data on meteorological and sound propagation conditions, and evaluation of the effectiveness of noise attenuation systems and devices that have been applied in this initial phase of operations. Noise monitoring for subsequent exploration wells at other drill sites will be modified as may be required based on the result of monitoring during the drilling of the first well.

The operator is responsible to assure that the equipments being used at the drilling site when located in a normal pattern relative to other operating systems, whether operating individually, or in combination, will not produce noise levels that exceed the prescribed standards. The meteorological conditions between source and receptor that exists at the time of any sound propagation will cause a given noise source to reach the receptor at different levels. For these reasons, it is considered that the county guidelines which provide for the monitoring of project noise levels at the initiation of drilling will enable the noise levels to be assessed in relation to the actual operation occurring at the drilling site and the effectiveness of the noise attenuation material/devices installed or designed into the various project equipments. From these data, measured at selected times when meteorological conditions would enhance sound propagation in the direction of the nearest residence, a determination can be made as to whether additional sound attenuation materials or devices need to be applied to one or more of the operating systems in order to remain in compliance with the Hawaii County noise guidelines.

After initial monitoring has demonstrated the general effectiveness of noise mitigation systems applied to the equipment used in the exploration drilling, selected noise monitoring will be conducted at each stage of development as new sites are occupied, as additional equipment and operating systems or new procedures are introduced into the project site and/or when an adverse meteorological condition exists that could cause noise standards to be exceeded. The purpose of the selected monitoring will be to continue to validate the noise propagation forecasts,and the effectiveness of the noise mitigation systems applied to the drill rig and associated equipment.

A meteorological monitoring station at the project site is essential to accumulate data on the range of adverse weather conditions that will cause sound to travel further or "focus" at random points. The residential areas (receptors) nearest the project boundary with the potential to experience noise levels in excess of the country guidelines are the two residences which are not only closest to the initial project activity, but which are either in a downwind location due to the nightly drainage winds or within an envelope in which stagnant air conditions at the project site could cause focusing of project sounds into these two receptor areas. These two areas are Kaohe Homesteads and Upper Kaimu Homesteads, approximately 1.9 miles from drill site A1. During normal tradewind conditions, the nearest downwind residential property is at a distance in excess of 7 miles.

Permission has been obtained from a resident in Kaohe Homesteads (the nearest residence to the first drilling site) to measure sound levels in their yard during evening hours on the day drilling begins and whenever project site weather conditions would indicate that sound propagation from the project site could be enhanced in the direction of their home. (Similar permission for noise monitoring in Upper Kaimu Homestead was not granted, therefore, another downwind residence near the project boundary has been selected to conduct the same monitoring approach as for Kaohe Homesteads). Project management will maintain continuing communications with these residents in order to demonstrate (1) the effectiveness of project noise mitigation measures under an expanding range of adverse meteorological conditions, or (2) the need to modify those mitigation measures.

As long as exploration drilling remains in the Northeastern portion of the subzone, it is believed that these two residential sound receptor locations will provide an accurate indication of the maximum, audible project noise sound levels that could be propagated into any surrounding community. However, noise level measurements of the drilling rig and associated equipment in operation at the initial drilling site will be made to determine whether there are basic directional characteristics in the sound propagation pattern. This knowledge will then be used when drilling at other drilling sites, if required, by orienting the equipment layout at the drilling sites so as to minimize sound propagation in the direction of the nearest residential receptors from the new drill site.

Detailed records will be maintained to provide the necessary data on which to modify the monitoring program. Records will indicate all reports of complaints about project noise, the name of the person(s) making the complaint, the project activity occurring at the time reported in the complaint, the meteorological conditions prevalent at the time of complaint and the action taken including, as may be required, sound monitoring at the complainant's residence by project personnel.

A project phone number and address will be furnished to community associations of the communities adjacent to the project boundary prior to initiating project operations. As authorized in the D & O, a mobile sound monitoring capability will be used. This will enable the operator to monitor noise levels at any of the nearby residences when requested or when a noise complaint is received.

Alternate monitoring sites will be selected as may be necessary when new project sites are occupied or if noise complaints are received from any resident near the project.

Archaeological Reconnaisance Survey Report

Geothermal Development Activities

(Exploration Phase)

Kilauea Middle East Rift Zone

Estate of James Campbell Property TMK 1-2-10:3

True/Mid-Pacific Geothermal Venture

January, 1999

Appendix D
Letter to DLNR
DATED:________

Attached is the report of our archaeological reconnaissance survey conducted within the conservation district along the access road alignment and the first drill site. The road alignment and drill site were surveyed and staked in order to identify the area to be surveyed which varied from two to five times the dimensions of the area to be disturbed as directed in the Decision and Order.

As indicated in the survey report, there were no findings of archaeological significance along the access road and first drill site.

Archaeological reconnaissance surveys will also be conducted in all other project sites to be used as those sites are selected. A research design plan will be submitted for approval if an archaeological find worthy of preservation or removal is discovered.

Appendix D
Ltr to DLNR
dtd________.

AN ARCHAEOLOGICAL RECONNAISSANCE SURVEY IN THE GEOTHERMAL RESOURCE SUBZONE OF UPPER KAIMU AND MAKENA, PUNA, HAWAII

by

WILLIAM J. BONK

UNIVERSITY OF HAWAII AT HILO

prepared for

MID-PACIFIC GEOTHERMAL, INC.

Hilo, Hawaii

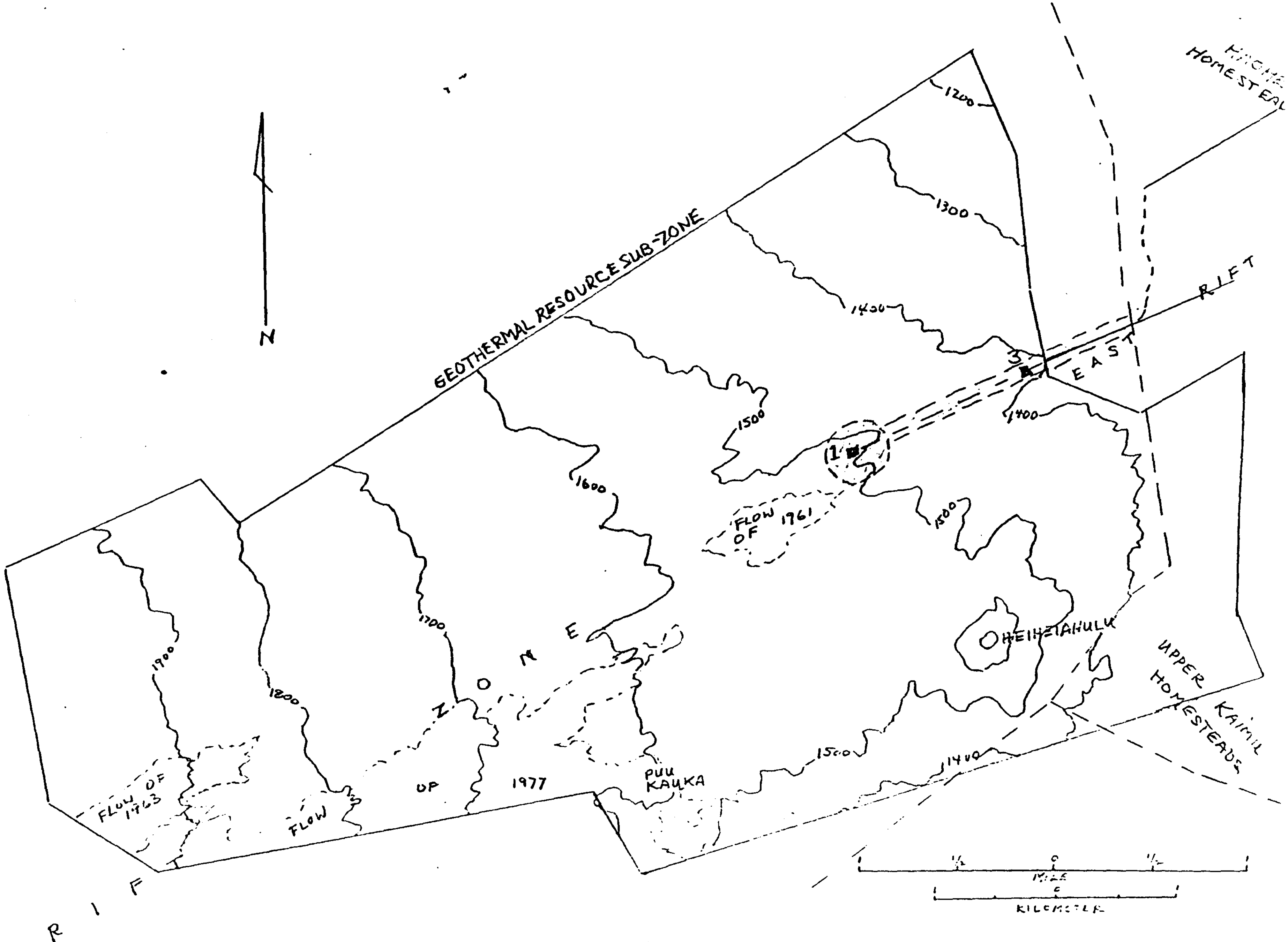
February, 1988

INTRODUCTION

In early October of 1987 the writer of this report received a telephone call from Mr. Rod Moss representing Mid-Pacific Geothermal, Inc. During the course of this conversation a request was made of me to conduct an archaeological reconnaissance survey on the property of the Estate of James Campbell in the Puna District, on the island of Hawaii. Specifically, the area to be investigated follows a proposed road alignment starting one-half of a mile outside of the geothermal resource sub-zone and culminating at the proposed drill site designated as A1 (See Map 1.)

After receiving pertinent information on location, permission to enter the land, as well as to cross other land, I received a "go-ahead" on October 28, 1987. Furthermore, I was asked to contact Mr. Nobu Santo at the offices of Island Survey Incorporated in Hilo where I would be able to aquire a copy of the survey map as well as information on access to the recently cleared survey line along the proposed road to the well site.

Mr. Santo was exceptionally helpful, even offering to accompany me through the neighboring lands to the survey start point on the boundary of Conservation District land. In early November we followed through with this plan. After arrival at his recently cut survey line through the forest Mr. Santo returned to Hilo and I proceeded to carry out the field reconnaissance portion of this investigation. The following pages of this report provides the results of this research.



GEOTHERMAL RESOURCE SUB-ZONE
N
1200
1300
1400
1500
1600
1700
1800
1900
EAST RIFT
3
1
FLOW OF 1961
ZONE
FLOW OF 1977
FLOW OF 1963
PUU KAUKA
HOMESTEADS
1/2
0
MILE
KILOMETER

Map 1

AREA

The area surveyed and reported on in this report is in the Puna District, on the island of Hawaii. It is on property of the Estate of James Campbell, Tax Map Key: 1-2-10:3. Here a planned access road of about 1.6 miles is planned to link the present Kaohe homestead road with a proposed geothermal drill site (See Map 1.) The road corridor with an addition of a buffer on each side (north and south) ranging between two to five times larger than the road corridor, was examined in the field. In addition, an area of approximately two acres surrounding the proposed drill site (A1) was added to the survey.

The archaeological reconnaissance started at the Conservation District boundary southeast of Kaohe Homesteads and extended into the Geothermal Resource Sub-zone along the northeast rift zone of Kilauea Volcano. It may be further be identified as being in the *ahupua'a* of Kaimu and Makena.

The area is extremely rugged, with several deep cracks, crevices, vent lines and deep tree molds along and adjacent to the proposed road corridor. Other than along the line cut through the forest by the engineer's survey crew that preceeded us to the area, the region examined is heavily covered with upland vegitation. *'Ohi'a* and ferns were encountered throughout the area checked. *Hapu'u* was especially numerous, and these together with the *'ohi'a* form the upper canopy of the forest. In most cases this reaches 30 to 65 feet in height and effectively restricts a good deal of the sunlight to the understory of the forest. Here other ferns such as *uluhe*, and vines such as *'ie'ie*, form a tangle underfoot. In addition guava (*Psidium guajava*), grasses and wild orchids make their appearance where sunlight filters through the vegetation canopy. Throughout the period in the field, the area was especially difficult to examine, for once off the survey centerline already cleared by the engineering crew visual inspection was limited to perhaps ten to twenty-five feet.

The study area shows an elevation ranging from a low of 1340 feet above sea level at the eastern starting point of the survey to a high of about 1530 feet at the drill site on the west (See Map 2.) Rainfall is fairly high and although there is no record for the immediate vicinity of the area of our concern I would expect something in the order of between 150 to 200 inches a year. Throughout most of the first day in the field rain fell almost constantly and at times very heavily. Low lying pockets of soil overlaying *pahoehoe* produces small muddy ponds of undertermined depth. In some cases I had to trample through these basins never really knowing how deep they might be. Fortunately I did not sink much more than a foot into the muck and cold water. Elsewhere insecure footing forced me on a number of occasions to slide to the bottom of an incline. Work under these conditions was anything but safe and secure.

Map 2
(Study area delineated)

METHODOLOGY AND FINDINGS

Basic field data for this report was obtained through a procedure or technique known as a reconnaissance survey. This is quite often the initial or preliminary archaeological examination. It normally includes visual observation and recording while walking over the area to be investigated. It includes note-taking, photographs where applicable, may add other illustrative methods of recording data, and always includes recommendations as to archaeological significance of the area so that it can be determined if further archaeological work is necessary.

In this instance I alone carried out the survey on the first day in the field although as previously mentioned I was accompanied by Mr. Nobu Santo. However, once at the beginning of the proposed road allignment he left me in order to return to Hilo while I proceeded to examine the road corridor, the buffer zone, the drill site, and the area surrounding the drill site. A total of ten hours were expended on that first day in the field. After working on the report I found I may not have covered the required width for the buffer zone to the north and south of the road corridor and I therefore returned a second day with my son Ken in order to insure the required coverage of an area "two to five times larger than the actual access road corridor." As a result, a total of 26 man hours, over a two-day period, was expended in field work.

As stated in the Land Board's decision of April 11, 1986, which set the requirements for the investigation, I conducted an archaeological reconnaissance survey for the access road to Drill Site A1, the drill site itself, and a buffer zone on each side of the road corridor and around the drill site (See Maps.) Throughout the field examination I found nothing to indicate past use of the study area. In other words I did not find the presence of any human activity remains within the area that I investigated. In addition to the 1.6 mile transect along the proposed road corridor we followed a second transect approximately 30 to 40 feet north of the centerline and roughly parallel to it, and a third parallel transect about equal distance south of the centerline. This gave us coverage of a corridor strip of 100 feet or more in width. Likewise, we investigated a similar buffer in the vicinity of the drill site. Here we must have examined close to three acres of land surrounding the mid-point of the drill site.

Previous archaeological fieldwork conducted by Paul H. Rosendahl, Ph.D., Inc. within the Geothermal Resource Subzone includes five transects north, southeast, and east of the area reported on in this report (Haun, et al, 1985.) In only one of these areas examined, that of transect five, did field crews come across probable archaeological remains. This included five to six cairns and mounds on the southeast summit of Heiheiahulu, some 1.1 miles south of the nearest area covered in our fieldwork.

In nearby Kahauale'a a reconnaissance survey was conducted by Hommon (1982) without finding anything of archaeological significance. Here too Rosendahl (1985) undertook a more recent field examination and again found nothing of cultural value. Additionally, an addendum by Rosendahl to the previously mentioned report by Haun and others (1985) reports on the use of a helicopter to make a low altitude aerial reconnaissance of the proposed development area. He landed and added a sixth transect to Haun's work. This transect is about three and a half miles west of our study area. On this trip Rosendahl also landed to examine an area adjacent to Haun's transect five at Heiheiahulu *pu'u*.

When we examine other than archaeological data we find nothing of a specific reference to the study area. Holmes (1982) mentions the U.S. Exploring Expedition of 1840 following a trail south of and paralleling the east rift zone from near Kalalua crater to Kapoho. He also mentions that the forest zone of Kahauale'a was exploited for its birds and for wood gathering. In addition, we read that the uplands of Kupahua, Kapaahu, Kaimu, Makena and Kalapana were extensively planted in aboriginal times (Handy and Handy, 1972.)

SUMMARY, CONCLUSIONS AND RECOMMENDATION

No archaeological sites, features or data supporting human activity within the study area was found during our investigation. Nonetheless, I caution those that might be tempted, therefore, to transfer an expectation or belief that other areas within the larger Geothermal Resource Subzone are also free of cultural remains. From an examination of the limited literature I would expect to find something, however confined the data. The likely location for cultural material coming to light is along or near the southern border and lands immediately to the south. Already found here are the only probable sites recorded to now. These are the few cairns and mounds near the summit of Heiheiahulu. Data of a non-archaeological nature also suggests the possibility of at least some use of the southern portion of the proposed development area and if this be true than the region between Pu'u Kauka and Heiheiahulu and the upper Kaimu Homesteads is perhaps the more likely location for cultural remains.

Finally, and in conclusion, let me reiterate my previous statement that no archaeological material was found during our survey of the area delineated in this report. Based on this, as well as my investigation of the limited literature, I find no archaeological significance for the area investigated and I therefore recommend no further work be required for that area.

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GLOSSARY OF HAWAIIAN WORDS

ahupua'a	A land division usually extending from the uplands to the sea. So called because the boundary was marked by a heep (*ahu*) of stones.
hapu'u	An endemic tree fern (Cibotium Sp.) common in many forests of Hawaii.
'ie'ie	An endemic woody, branching climber (Freycinetia arborea) growing luxuriantly in forests at altitudes of about 1500 feet.
'ōhi'a	A tree (Metrosideros macropus, M. collina).
pahoehoe	Smooth, unbroken type of lava. As contrasted with *'a'a*.
pu'u	Any kind of a protuberance. A hill, peak, mound, bulge, heap, knob, etc.
uluhe	All Hawaiian species of false staghorn fern (Dicranopteris linearis).

<u>Biological Survey Report</u>

<u>Geothermal Development Activities</u>

(Exploration Phase)

Kilauea Middle East Rift Zone

Estate of James Campbell Property TMK 1-2-10:3

True/Mid-Pacific Geothermal Venture

January, 1989

Appendix E
Letter to DLNR
DATED:________

Attached is a report of a biological survey of the land areas to be impacted by clearing and grading for an access road and drilling site within the geothermal project site. The area surveyed was two to five times larger than the dimensions of the areas to be cleared for project activities. As indicated in the report, no endangered species were sighted along the access road and around the first drilling site. However, based on the survey's sighting of two trees being considered for listing by the U.S. Fish and Wildlife Service as endangered species (Bobea timonioides and Tetraplasandra) along or adjacent to the access road, the road will be deviated east of survey stakes #48 and #58 (Figure 1-A) to avoid these trees. In addition, the drill site, A1, will be relocated east of the originally designated site by 300 feet to avoid clearing an area of 'Ohi'a a-(2) forest which contains a resident population of a native bird (not endangered), the Hawai'i 'elepaio.

Biological surveys will also be conducted in all other project sites to be used as those sites are selected. These surveyed areas establish a baseline of biological data for monitoring future impacts that are the result of project activity. While numerous exotic plants are evident along the access route and around the first drill site periodic biological monitoring surveys will be conducted in these areas with particular emphasis along roads and clearings to assess the introduction or spread of existing exotic plants in and adjacent to the cleared areas and to provide the basis for determining the need for control measures to limit further spread of such plants. The results of the periodic follow-up surveys and proposed methods for control of exotic plants adjacent to areas cleared for project operations will be submitted to DLNR for review and approval.

During the continuation and expansion of project activities, any areas encountered that are determined to be appropriate for designation as botanical sanctuaries will be reported to the land owner as a basis for discussion with DLNR.

Water Analysis.

The D & O also required that water samples be collected for analysis prior to initiating drilling of the first well in each development area, and after completion of well testing. A licenced water quality testing laboratory will collect samples of water from laboratory catchment containers for analysis in the nearest residential area which is in a prevailing downwind direction from the drilling site. Results will be submitted to DLNR, the Health Department, and the County of Hawaii.

BIOLOGICAL SURVEY

OF THE

PROPOSED ACCESS ROAD

AND

WELL SITE 1

BLNR DESIGNATED GEOTHERMAL RESOURCE SUBZONE

MIDDLE EAST RIFT ZONE OF KILAUEA

PUNA DISTRICT, ISLAND OF HAWAI'I

November 14, 1987

by

Charles H. Lamoureux

Winona P. Char

Paul Higashino

Maile S. Kjargaard

PREPARED FOR:

TRUE/MID PACIFIC GEOTHERMAL VENTURE

INTRODUCTION

On 14 November 1987 a biological baseline survey was conducted of the proposed access road and well site 1. The road and well site had recently been surveyed and staked; reference is made throughout this report to "stake #__", the surveyor's stakes placed at irregular intervals along the access road. Their locations are indicated on FIG. 1.

METHODOLOGY

The study covered the areas between stake # 48 (just outside, or east of, the conservation district boundary) and stake # 67 (at well site 1). The ornithologist proceeded in advance of the botanists, to avoid undue disturbance to birds, and at each stake she conducted a standard 8-minute census of all birds seen or heard.

The botanists surveyed an area of 75 to 100 feet in width with its center line along the center line of the road alignment. In three places where the proposed road alignment deviated to the south of the surveyor's line to avoid geological hazards, (between stakes 48 and 50, with a deviation of 50 feet at stake 49; between stakes 55 and 57, with a deviation of 50 feet at stake 56; between stakes 58 and 60, with a deviation of 150 feet at stake 59), the center line of the survey area followed the proposed road alignment rather than the surveyor's line. At well site 1 an area of about 500 feet square was surveyed, centered on

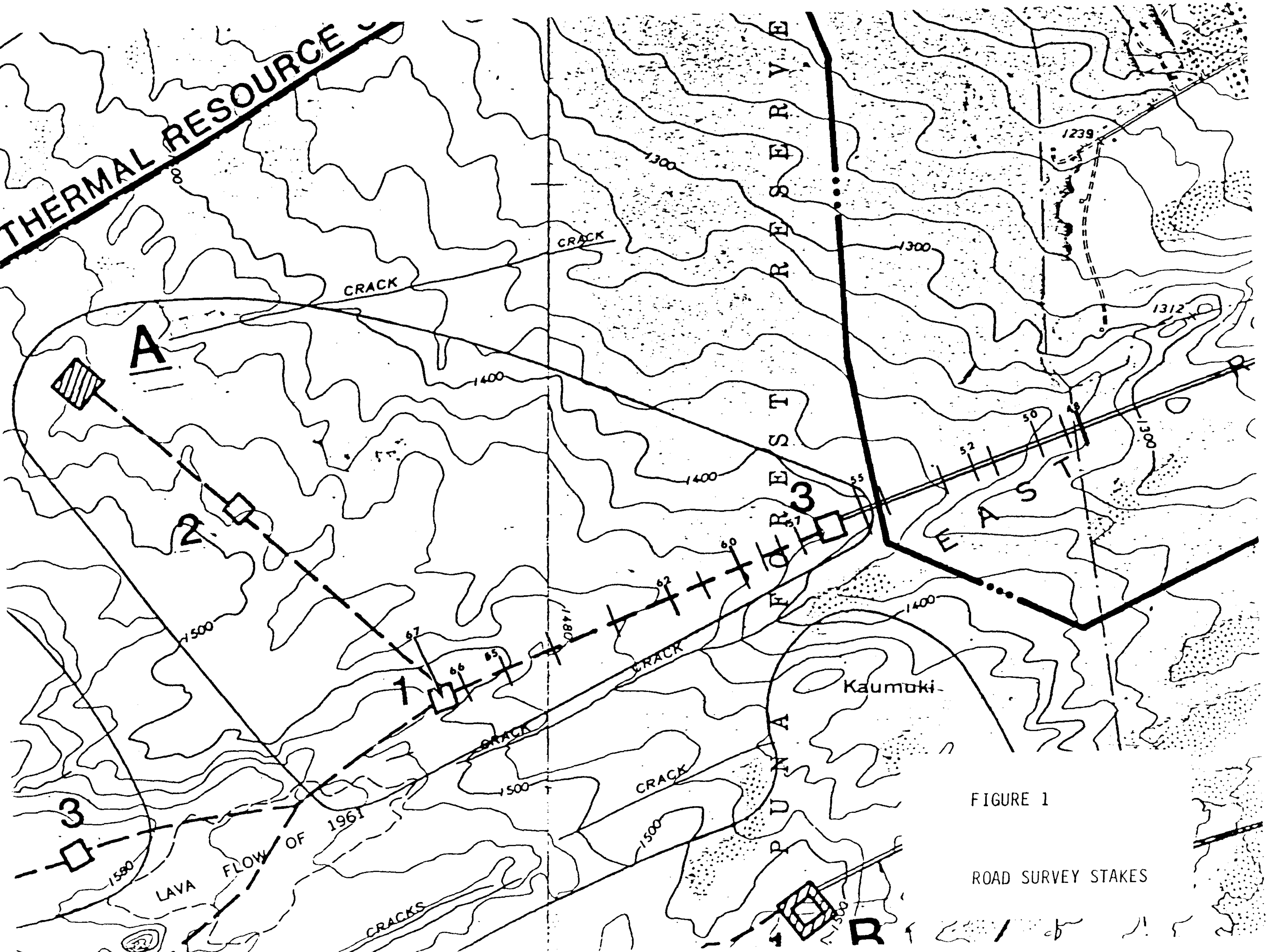

FIGURE 1

ROAD SURVEY STAKES

stake 67, i.e., an area about twice as great as the proposed area to be cleared for well site 1. All vascular plant species encountered were recorded, and notes made of their abundance. Observations of vegetation structure were made, including information on size and condition of dominant tree species, extent of canopy cover, and nature and extent of the subcanopy and understory.

RESULTS

1. FLORA

All species of vascular plants observed are listed in TABLE I. A total of 103 species and varieties were found, of which 68 were native, (51 endemic to the Hawaiian islands, 17 indigenous, native in Hawai'i and elsewhere), and 35 were species introduced to Hawai'i by humans (3 by the Polynesian settlers, 32 since European contact).

Two species were encountered which are being considered for listing by the U. S. Fish and Wildlife Service (1980) as endangered species: <u>Bobea timonioides</u> (Hook. f.) Hillebr. and <u>Tetraplasandra hawaiiensis</u> Gray var. <u>hawaiiensis</u>.

<u>Bobea timonioides</u> is a Category 1 species, one for which the Service had sufficient information to support the biological appropriateness of listing, but for which data still needed to be collected concerning the environmental and economic impacts of listing and designation of Critical Habitat. It has been found in many places in the Puna District in recent years.

Tetraplasandra hawaiiensis var. hawaiiensis is a Category 2 species, for which the Service had information to support the probable appropriateness of listing as endangered or threatened, but for which sufficient information was not yet available to biologically support a proposed rule. It is not currently considered a high priority item for listing since its range has been shown to be more extensive than previously believed.

2. VEGETATION

The vegetation of the Puna Geothermal Area had previously been described and mapped (Char and Lamoureux, 1985a, 1985b)

Most of the road and the well site are in forest described in earlier reports as Wet 'ohi'a forest with native species and exotic shrubs, and delimited on the vegetation maps in Char and Lamoureux, (1985a) as "ohia-a(2)". This forest is dominated by 'ohi'a-lehua (three varieties of Metrosideros collina), which forms the canopy layer. Trees are mature, ranging from 20 to 60 feet in height. In some places the canopy is closed (>60% cover) with most or all trees healthy, in other places more open and many of the trees are dead. In other words there are patches of 'ohi'a dieback in the forest. The more common subcanopy trees include both native species, (kopiko - Psychotria hawaiiensis, kawa'u - Ilex anomala, and hame - Antidesma platyphyllum), and introduced species, (guava - Psidium guajava and strawberry guava - Psidium cattleianum). Tree ferns (hapu'u - *Cibotium glaucum* and hapu'u 'i'i - *Cibotium chamissoi*) are common. The dominant shrub throughout the area is the introduced weedy Malabar melastome (*Melastoma malabathricum*), but some native shrubs are relatively common, including kanawao (*Broussaisia arguta*), mamaki (*Pipturus hawaiiensis*), 'ohelo (*Vaccinium calycinum*), *Clermontia parviflora*, and *Cyrtandra paludosa*, along with the introduced thimbleberry (*Rubus rosaefolius*). In more closed parts of the forest the trees, tree ferns, and shrubs support dense masses of epiphytes, including many ferns (listed in Table I), mosses and liverworts. In more open places there are extensive patches of uluhe ferns (*Dicranopteris emarginata* and *D. linearis*) 3 to 8 feet deep.

Between stakes 64 and 66 is an area where the 'ohi'a trees are very widely scattered and the uluhe fern is particularly dense. This area was described as *'Ohi'a woodland with uluhe*, and designated as "ohia - uluhe" on vegetation maps in our earlier report (Char and Lamoureux, 1985a).

At well site one the 'ohi'a forest was composed of fairly small trees, 25 to 30 feet tall, with an open canopy. There was a dense understory of Malabar melastome (about 60% cover). This area may have been used by humans in the past, since the only kukui tree (*Aleurites moluccana*) and 'awapuhi ginger (*Zingiber zerumbet*) we found were at this site.

We noted signs of feral pig activity throughout the area, and encountered one sow with young during our survey. In places where pigs have rooted, and in small open wet areas where they have wallowed, are a number of introduced weeds which are usually not found in undisturbed forest. These include a fern (Athyriopsis japonica), broomsedge (Andropogon virginicus), Californiagrass (Brachiaria mutica), Hilograss (Paspalum conjugatum), a sedge (Cyperus haspan), waterpurselane (Ludwigia palustris), St. Johnswort (Hypericum mutilum), drymaria (Drymaria cordata), and fireweed (Erechtites valerianaefolia). A few small taro plants (Colocasia esculenta) were found in some old wallows.

3. AVIFAUNA

See separate report by Kjargaard attached as APPENDIX I.

ENDANGERED SPECIES

1. Bobea timonioides: Two trees of this Category 1 plant were encountered. One was just at the conservation district boundary, and about 5 feet north of the surveyor's line. At this point the road is planned to veer southward, and if the curve to the south begins perhaps 50 feet outside the conservation district line, instead of right on the line, this tree can be avoided. The second tree is about 50 feet east of stake 58 and about 5 feet north of the surveyor's line. The road is planned to veer south starting at stake 58. If the curve to the south were to begin perhaps 100 feet east of stake 58 this tree can be avoided.

2. _Tetraplasandra hawaiiensis:_ About half a dozen trees of this Category 2 species were found. All but one was more than 20 feet from the centerline of the proposed road should not be damaged by road construction. The one exception is close to the first _Bobea_ tree, right at the conservation district boundary, but about 10 feet south of the surveyor's line. At this point the road is supposed to veer southward. If, as suggested in the paragraph above, the southward curve were to begin slightly outside the conservation district , instead of just at the boundary, this tree could be avoided too.

3. _Adenophorus periens:_ A special search was made for this Category 1 plant. We did not find any. This area is below the elevation the elevation where this fern is known to occur in Puna. Also, most of the 'ohi'a trees in the area are characterized by having bark that peels off in large strips. Since these trees shed their bark regularly, they do not develop the dense coating of mosses and liverworts on their bark which forms the substrate on which _A. periens_ grows.

4. _Buteo solitarius:_ The Hawaiian hawk, or 'I'o, was not encountered during our survey, although it undoubtedly occurs in the area. The proposed construction would be unlikely to have significant adverse effects on the hawk population, unless nests were to be destroyed. We did not find any nests along the proposed road or at the well site.

RECOMMENDATIONS

1. No listed endangered species were encountered during our survey, but three trees were found which could be damaged by road construction. We recommend that, in the two places specified above, the planned southward deviation of the road from the surveyor's line should begin a few feet east of the places indicated on the surveyor's plan, thus avoiding these trees.

2. The area now contains a large population of introduced woody shrubs and trees, particularly Malabar melastome, strawberry guava, and guava. It is unlikely that construction activities will have much effect on their abundance or distribution. However, there are several other weeds that could increase in numbers and become more widely distributed as a consequence of opening up the forest as construction occurs. These are the species currently associated with pig-disturbed areas, such as broomsedge, Californiagrass, Hilograss, *Cyperus haspan*, and fireweed. Other weeds, not now in the area, could also enter. To avoid this we recommend that:

a. road construction methods should be planned to involve as little disturbance as possible beyond the edge of the road. This might include using soil and rocks from high points to fill in low spots rather than bulldozing them into ridges at the sides of the road.

b. the well site and road margins be monitored for weeds, and that appropriate weed control methods be used on all cleared areas. (Appropriate methods might include both mechanical methods and judicious use of approved herbicides such as weed oil or Roundup).

3. Our observations elsewhere suggest that unpaved road margins and open roadsides are prime sites for weed colonization. Most weedy species require high light intensities to grow well, and such sites are open to full sunlight. If such areas are kept shaded they are less likely to be colonized by weeds. Thus as few trees as possible should be be removed from roadsides. During construction if trees are simply bulldozed aside and, with other vegetation, rocks, and soil are piled up into windrows, these rubble piles will soon be covered with weeds. In the construction process many 'ohi'a trees will be cut. The wood they produce may constitute a resource valuable enough to make it worth selling and trucking the logs off the site, which would significantly reduce the volume of rubble piles. We recommend that you look into the feasibility of this.

4. A lot of good quality tree fern (hapu'u and hapu'u-'i'i) will also have to be removed during construction. The fern logs should be marketable to orchid growers or nurseries, and should more than repay the cost of hauling them off the site. However, the top foot or two of each fern stem, containing the apical bud, should be retained and replanted on the site. This would meet the state requirement that any landscaping be done with native species. More importantly, it would provide a quick source of shade on rubble piles and road margins, which should reduce the

weed problem.

5. We have looked at the area around the proposed well site to see if there are nearby areas where clearing the site would have different environmental impacts. The site now designated is an area of 'ohi'a a-(2) forest, but just to the east is a more open 'ohi'a - uluhe woodland. Selecting a well site in the woodland would involve cutting fewer trees than in the forest. However, the forest at the designated site is botanically degraded, with a very dense understory of Malabar melastome. The uluhe fern in the woodland is a native Hawaiian species, which results in the percentage of cover of native species being higher in the woodland than in this particular patch of forest. No rare species were found in either site. Thus, from a botanical standpoint the currently designated well site seems appropriate. On the other hand, there is a resident population of a native bird, the Hawai'i 'elepaio in the forest site but not in the woodland. While birds are able to move to avoid construction activities, the 'elepaio tends to be territorial in its habits and may not move as easily as some other species. It was rare along the proposed roadway, and the largest population encountered was at the well site. The 'elepaio is not listed as an endangered species. Taking all this into account, there is no compelling environmental reason to shift the well site a few hundred feet eastward, but you may want to consider this option if the geology of the site is as favorable as that at the currently designated site.

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TABLE 1. PLANT SPECIES CHECKLIST

Families are arranged alphabetically within each of three groups: Ferns and Fern Allies, Monocotyledons, and Dicotyledons. Taxonomy and nomenclature of the Ferns and Fern Allies follow Lamoureux's unpublished checklist of Hawaiian ferns; taxonomy and nomenclature of the flowering plants (Monocotyledons and Dicotyledons) follow St. John (1973) except where more commonly accepted names are listed. Hawaiian names used in the checklist are in accordance with Porter (1972) or St. John (1973).

For each species the following information is provided:

1. Scientific name with author citation.
2. Common English or Hawaiian name, when known.
3. Biogeographic status of the species. The following symbols are used:

   E = endemic = native to the Hawaiian Islands only, not occurring naturally elsewhere.

   I = indigenous = native to the Hawaiian Islands and also to one or more other geographic areas.

   P = Polynesian = plants of Polynesian introduction; all those plants brought by the Polynesian immigrants prior to contact with the Western world.

   X = exotic or introduced = not native to the Hawaiian Islands; brought here intentionally or accidentally by man after Western contact.

TABLE I.

PUNA GEOTHERMAL AREA
PLANT CHECKLIST: ACCESS ROAD AND WELL SITE 1

STATUS	BOTANICAL NAME	COMMON NAME
ASPLENIACEAE		
I	Asplenium lobulatum Mett.	pi'ipi'i-lau-manamana, 'anali'i
I	Asplenium nidus L.	'ekaha
ATHYRIACEAE		
X	Athyriopsis japonica (Thunb.) Ching	
E	Diplazium sandwichianum (Presl) Diels	ho'i'o
BLECHNACEAE		
X	Blechnum occidentale L.	blechnum fern
DENNSTAEDTIACEAE		
I	Microlepia strigosa (Thunb.) Presl	palai, palapalai
DICKSONIACEAE		
E	Cibotium chamissoi Kaulf.	hapu'u-'i'i
E	Cibotium glaucum (J. Sm.) Hook. & Arn.	hapu'u
ELAPHOGLOSSACEAE		
E	Elaphoglossum alatum Gaud. var. parvisquameum (Skottsb.) Ands. & Crosby	'ekaha-ula, hoe-a-Maui
E	Elaphoglossum crassifolium (Gaud.) And. & Crosby	'ekaha-ula, hoe-a-Maui
E	Elaphoglossum hirtum (Sw.) C. Chr. var. micans (Mett.) C. Chr.	'ekaha-ula, hoe-a-Maui
E	Elaphoglossum pellucidum Gaud.	'ekaha-ula, hoe-a-Maui
E	Elaphoglossum wawrae (Luerss.) C. Chr.	'ekaha-ula, hoe-a-Maui
GLEICHENIACEAE		
E	Dicranopteris emarginata (Brack.) Rob.	uluhe
I	Dicranopteris linearis (Burm.) Underw.	uluhe
GRAMMITACEAE		
E	Adenophorus hymenophylloides (Kaulf.) Hook. & Grev.	pai, palai-huna
E	Adenophorus pinnatifidus Gaud.	
E	Adenophorus tamariscinus (Kaulf.) Hook. & Grev. var. tamariscinus	wahine-noho-mauna
E	Adenophorus tripinnatifidus Gaud.	
E	Grammitis tenella Kaulf.	kolokolo, mahina-lua
HYMENOPHYLLACEAE		
E	Callistopteris baldwinii (Eaton) Copel.	
I	Gonocormus minutus (Blume) v. d. Bosch	
E	Mecodium recurvum (Gaud.) Copel.	'ohi'a-ku
E	Sphaerocionium lanceolatum (Hook. & Arn.) Copel.	palai-hinahina
E	Sphaerocionium obtusum (Hook. & Arn.) Copel.	Palai-lau-li'i

STATUS	BOTANICAL NAME	COMMON NAME
E	Vandenboschia cyrtotheca (Hillebr.) Copel.	
E	Vandenboschia davallioides (Gaud.) Copel.	palai-hihi
LINDSAEACEAE		
I	Sphenomeris chinensis (L.) Maxon	pala'a, palapala'a
LYCOPODIACEAE		
E	Lycopodium phyllanthum Hook. & Arn.	wawae-'iole
MARATTIACEAE		
E	Marattia douglasii (Presl) Baker	pala, kapua'i hoki
NEPHROLEPIDACEAE		
I	Nephrolepis cordifolia (L.) Presl	ni'ani'au, kupukupu,'okupukupu
I	Nephrolepis exaltata (L.) Schott	ni'ani'au, kupukupu, pamoho
X	Nephrolepis multiflora (Roxb.) Jarrett ex Morton	hairy sword fern
OPHIOGLOSSACEAE		
E	Ophioglossum pendulum L. ssp. falcatum (Presl) Clausen	puapua-moa
POLYPODIACEAE		
I	Pleopeltis thunbergiana Kaulf.	'ekaha-'akolea, pakahakaha
PSILOTACEAE		
I	Psilotum complanatum Sw.	moa, pipi
I	Psilotum complanatum X nudum	hybrid moa
I	Psilotum nudum (L.) Beauv.	moa, pipi
SELAGINELLACEAE		
E	Selaginella arbuscula (Kaulf.) Spring	lepelepe-a-moa
THELYPTERIDACEAE		
X	Christella dentata (Forsk.) Brownsey & Jermy	downy woodfern
X	Christella parasitica (L.) Levl.	woodfern, oakfern
X	Macrothelypteris torresiana (Gaud.) Ching	
E	Pneumatopteris sandwicensis (Brack.) Holtt.	
ARACEAE		
P	Colocasia esculenta (L.) Schott	kalo, taro
CYPERACEAE		
X	Cyperus haspan L.	
X	Kyllingia brevifolia Rottb.	kili'o'opu, kyllingia
I	Machaerina mariscoides (Gaud.) Kern ssp. meyenii (Kunth) Koyama	'uki, 'aha-niu

STATUS	BOTANICAL NAME	COMMON NAME
E	Rhynchospora lavarum Gaud.	kuolohia, pu'uko'a
GRAMINEAE		
X	Andropogon virginicus L.	broomsedge
X	Axonopus affinis Chase	narrow-leaved carpetgrass
X	Brachiaria mutica (Forsk.) Stapf	Californiagrass
X	Oplismenus hirtellus (L.) Beauv.	honohono-kukui, basketgrass
X	Paspalum conjugatum Berg.	mau'u-Hilo, Hilo grass
X	Paspalum orbiculare Forst. f.	mau'u-laiki, ricegrass
X	Sacciolepis indica (L.) Chase	Glenwoodgrass
LILIACEAE		
E	Smilax sandwicensis Kunth	hoi-kuahiwi
ORCHIDACEAE		
X	Arundina bambusaefolia (Roxb.) Lindl.	bamboo orchid
X	Spathoglottis plicata Bl.	Philippine ground orchid
PANDANACEAE		
E	Freycinetia arborea Gaud.	'ie'ie
ZINGIBERACEAE		
P	Zingiber zerumbet (L.) Roscoe	'awapuhi kua hiwi
APOCYNACEAE		
E	Alyxia olivaeformis Gaud.	maile
AQUIFOLIACEAE		
E	Ilex anomala Hook. & Arn.	kawa'u
ARALIACEAE		
E	Tetraplasandra hawaiensis Gray var. hawaiensis	'ohe
CARYOPHYLLACEAE		
X	Drymaria cordata (L.) Willd. ex R. & S.	drymaria, pipili
COMPOSITAE		
I	Adenostemma lavenia (L.) Ktze.	kamanamana
X	Ageratum conyzoides L.	ageratum, maile-hohono
X	Ageratum houstonianum Mill.	ageratum
X	Erechtites valerianaefolia (Wolf) DC.	fireweed
X	Eupatorium riparium Regel	Hamakua pamakani
ERICACEAE		
E	Vaccinium calycinum Sm.	'ohelo-kau-la'au

STATUS	BOTANICAL NAME	COMMON NAME
EUPHORBIACEAE		
P	Aleurites moluccana (L.) Willd.	kukui
E	Antidesma platyphyllum Mann	hame
GESNERIACEAE		
E	Cyrtandra paludosa Gaud. var. integrifolia Hillebr.	
E	Cyrtandra paludosa Gaud. var. irrostrata St.John	
GUTTIFERAE		
X	Hypericum mutilum L.	St. Johnswort
LOBELIACEAE		
E	Clermontia hawaiiensis (Hillebr.) Rock	'oha-kepau
E	Clermontia parviflora Gaud. ex Gray	
LYTHRACEAE		
X	Cuphea carthagenensis (Jacq.) Macbride	cuphea, puakamoli
MELASTOMATACEAE		
X	Melastoma malabathricum L.	Malabar melastome
MYRSINACEAE		
E	Myrsine lessertiana A. DC.	kolea-lau-nui
MYRTACEAE		
E	Metrosideros collina (J.R. & G. Forst.) Gray var. glaberrima (Levl.) Rock	'ohi'a-lehua
E	Metrosideros collina (J.R. & G. Forst.) Gray var. incana (Levl.) Rock	'ohi'a-lehua
E	Metrosideros collina (J.R. & G. Forst.) Gray var. macrophylla Rock	'ohi'a-lehua
X	Psidium cattleianum Sabine forma cattleianum	strawberry guava, waiawi-'ulua
X	Psidium cattleianum Sabine forma lucidum Deg.	yellow strawberry guava,waiawi
X	Psidium guajava L.	guava, kuawa
NYCTAGINACEAE		
I	Pisonia umbellifera (J.R. & G. Forst.) Seem.	papala-kepau
ONAGRACEAE		
I	Ludwigia octivalvis (Jacq.) Raven	kamole, primrose willow
X	Ludwigia palustris (L.) Ell.	water purselane
PIPERACEAE		
E	Peperomia cookiana C. Dc.	'ala'ala-wai-nui
E	Peperomia hypoleuca Miq. var. hypoleuca	'ala'ala-wai-nui
E	Peperomia latifolia Miq.	'ala'ala-wai-nui

STATUS	BOTANICAL NAME	COMMON NAME
I	Peperomia tetraphylla (Forst. f.) Hook. & Arn. var. tetraphylla	'ala'ala-wai-nui
ROSACEAE		
X	Rubus rosaefolius Sm.	thimbleberry
RUBIACEAE		
E	Bobea timonioides (Hook. f.) Hillebr.	'ahakea
E	Coprosma ochracea Oliver var. rockiana Oliver	pilo, kopa
E	Gouldia terminalis (Hook. & Arn.) Hillebr.	manono
X	Paederia foetida L.	maile pilau
E	Psychotria hawaiiensis (Gray) Fosb. var. hawaiiensis	kopiko
RUTACEAE		
E	Pelea clusiaefolia Gray var. cuneata St. John & Hume	alani
SAXIFRAGACEAE		
E	Broussaisia arguta Gaud.	kanawao
UMBELLIFERAE		
X	Centella asiatica (L.) Urban	Asiatic pennywort, pohekula
URTICACEAE		
E	Pipturus hawaiensis Levl.	mamaki

APPENDIX I

Baseline avian survey, proposed access road and wellsite A1, geothermal resource subzone, Puna Forest Reserve, Puna, Hawaii.

Maile S. Kjargaard, Volcano, Hawaii
November 14, 1987.

A. Methods

I conducted standard eight minute censuses (see Ramsey and Scott, 1979 for methods) at designated stake numbers from the conservation zone boundary to the wellsite . All birds seen or heard were counted during these intervals. Observations of unusual species or pertinent biological details made between stations were also noted.

B. Annotated species list

Status symbols follow Pyle (1983) (see attached sheet), scientific and vernacular names follow the 6th edition of the AOU Checklist of North American Birds (1983).

FAMILY PHASIANIDAE (QUAILS, PHEASANTS, FRANCOLINS)
Lophura leucomelana Kalij Pheasant
Fn

Rare; apparantly not particularly selective about subcanopy composition where it occurs in the survey area since it was found in both major vegetation types .

FAMILY TIMALIIDAE (BABBLERS)
Garrulax canorus Melodious Laughing-thrush
Fl

Common in the lower portion of the study area; rarer in the less disturbed regions near the proposed wellsite.

FAMILY TURDIDAE (THRUSHES)
Phaeornis obscurus obscurus 'Oma'o, Hawaii Thrush
Re

Present in low numbers throughout, but more frequently observed in the upper part of the site (stations 56-67).

FAMILY MUSICAPIDAE (OLD WORLD FLYCATCHERS
Chasiempis sandwichensis sandwichensis Hawaii 'Elepaio
Re

One substantial population present at the upper part of the study area, otherwise rare. Vigorous low elevation populations of this species are no longer as common as they once were as recently as a decade ago.

FAMILY ZOSTEROPIDAE (WHITE-EYES)
Zosterops japonicus Japanese White-eye
Fl

0Abundant and widely distributed, present in all habitat types.

FAMILY FRINGILLIDAE (FINCHES, CARDINALS, HAWAIIAN HONEYCREEPERS)
Cardinalis cardinalis Cardinal
Fl

One population occured in the more disturbed lower portion of the study area.

Carpodacus mexicanus House Finch
Fl

Present in the lower part of the site; the occurence of this species appeared to be positively correlated with the presence of dense stands of strawberry guava.

Hemignathus virens virens Hawaii 'Amakihi
Re

Found in low numbers throughout the site, but slightly more common in the upper portion of the proposed road and in the vicinity of the wellsite.
Nest construction by an individual of this species observed at stake 53.

Himatione sanguinea sanguinea 'Apapane
Re

Widely distributed and common, most abundant in the upper half of the study site. Highest densities occur in all vegetation types which have a healthy poopulation of Metrosideros; stand-level dieback areas had significantly fewer native bird species as a whole.

Vestiaria coccinea 'I'iwi

Rare. One questionable detection of this species occured at station 52.

C. General field observations and recommendations

1. Native bird observations were most frequent in the less disturbed upper portion of the study area. Within these areas, densities of the honeycreeper species appeared to be more correlated with the vigor and density of Metrosideros than with the composition of the understory flora. 'Elepaio and Thrush densities were probably more sensitive to the characteristics of the subcanopy since neither are nectivorous ('Elepaio feed primarily on insects, while Thrush will take both fruit and insects).

2. Extraordinarily high mosquito densities at stations 53 through 61 did not appear to be negatively correlated with presence of native forest birds. My inability to stand quietly during census periods at these stations may be partially responsible for the precipitous drop in species diversity after station 53 (though see comments below, #4).

3. No Hawaiian Hawk were found in the area. However, this species in notoriously difficult to census in forested areas, and

they are undoubtedly present here as the habitat is appropriate for them, and there are high densities of Hawk in nearby locations (pers. obs.).

4. Alien bird species diversity declined noticibly after station 53 (with the exception of the Japanese White-eye). The species that dropped out here were those that feed primarily on seeds and fruit (eg., the Cardinal, House Finch and Melodious Laughing-thrush), indicating that the decline may be correlated with a decrease in density of certain food plants such as waiwi and strawberry guava.

5. This area remains viable as avian habitat in spite of invasion of numerous weedy plant species; such habitat in low elevation areas is becoming more and more scarce as developmental demands increase. My preference would be for geothermal development to be concentrated in locations that have already been perturbed rather than opening up new parcels of forest; as such is obviosly not an option in this case, the following recommendations for mitigation are appropriate:

a) If possible, deviate the road away from present avian "hot spots" such as the ʻElepaio population at stations 66 and 67, and the vigorous stands of Metrosideros in the vicinity of stations 60 and 61.

b) Impact on native forest bird populations could be reduced by locating power plants and well sites in areas of stand-level dieback and/or high alien plant species density where native bird populations have already been depressed.

D. Raw data

The table below gives the results of 20 censuses performed at designated stake numbers along the proposed access road and at the proposed wellsite, expressed as number of individuals of each species.

SPECIES	STATION																			
	48	9	50	1	2	3	4	5	6	7	8	9	60	1	2	3	4	5	6	7
Lophura leucomelana						1										1				
Garrulax canorus		3	4	1	1	2												1		
Phaeornis o. obscurus		1							1	1		1		2			2			
Chasiempis s. sandwichensis						1													4	2
Zosterops japonicus	7	3	4	2	3	2	2	2		3	1	4	5	2	5	3	4	3	4	6
Cardinalis cardinalis			1	2		2														
Carpodacus mexicanus			4	1	2	1	2													
Hemignathus v. virens		1	1			1		1		1				1			1	2	1	3
Himatione s. sanguinea	2	3	1		2	1	3	6	4	6	4	3	3	9	8	6	4	4	3	9
Vestiaria coccinea					1*															

*uncertain record, not visually confirmed.

E. Literature cited

American Ornithologist's Union (1983) Check-list of North American Birds, ed., Baltimore, AOU.

Pyle, R. (1983) Checklist of the birds of Hawaii. 'Elepaio 44:47-58.

Ramsey, F. L., and J. M. Scott (1979) Estimating population densities from variable circular plot surveys. In R. M. Cormack et. al., eds., Sampling Biological Populations. International Cooperativ Publishing House, Fairland, Md.

STATUS SYMBOLS

RESIDENT SPECIES; NATIVE

Re = Resident--endemic at species level;
not extinct
Ri = Resident--indigenous species;
Hawaiian form not endemic
Ris = Resident--indigenous species;
Hawaiian subspecies endemic

FOREIGN OR INTRODUCED SPECIES; RESIDENT

Fl = Foreign--long-established;
breeding for more than 25 years
Fn = Foreign--new introduction;
apparently established and breeding,
but for less than 25 years

BREEDING SPECIES IN HAWAI'I; NATIVE; MOST INDIVIDUALS LEAVE HAWAI'I WHEN NOT BREEDING

Bi = Breeder--indigenous species;
Hawaiian form also breeds elsewhere
Bis = Breeder--indigenous species;
Hawaiian subspecies breeds only in
Hawaiian Islands

VISITOR SPECIES; BREEDS ELSEWHERE; OCCURS IN HAWAI'I WHEN NOT BREEDING

Vr = Visitor--regular migrant

ENDANGERED SPECIES (*)

An asterisk preceding the scientific name of the bird indicates that the species is currently on the federal list of endangered species (U. S. Fish & Wildlife Service 1979).

Emergency Plan

Geothermal Development Activities

(Exploration Phase)

Kilauea Middle East Rift Zone

Estate of James Campbell Property TMK 1-2-10:3

True/Mid-Pacific Geothermal Venture

January, 1989

Appendix F
Letter to DLNR
DATED:________

EMERGENCY CONTACT LIST

COUNTY	BUS./RES. PHONE NUMBERS	
Civil Defense	(808) 935-0031	
	(808) 935-3311	(After-hours/holidays)
Police Dept.	(808) 935-3311	(Emergency)
	(808) 966-9388	Keaau Police Station)
	(808) 961-2211	(Hilo Police Station)
Fire Dept.	(808) 961-6022	Ambul/Paramed/Rescue

STATE

DLNR:	Division of Water & Land	(808) 548-7533/988-6541
DOH:	Pollution Investigation & Environmental Enforcement Branch	(808) 548-6355

FEDERAL

Hawaii Volcanoes Observatory	(808) 967-7328
Hawaii Volcanoes Nat. Park	(808) 967-7311
Weather Rpt. Recording	(808) 935-8555/961-5582
Volcano Rpt. Recording	(808) 967-7977

KEY PROJECT PERSONNEL

Hawaii

Project Site	(808) ________	
Gary Hoggatt	(808) 528-3496	Drilling Supervisor
Allan Kawada	(808) 528-3496	Administrative Coordinator True Geothermal Energy Co.
Rod Moss	(808) 521-9004	Mid-Pacific Geothermal, Inc.

Wyoming

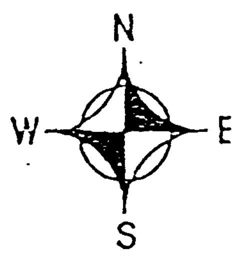
True Companies (HQ)	(307) 237-9301

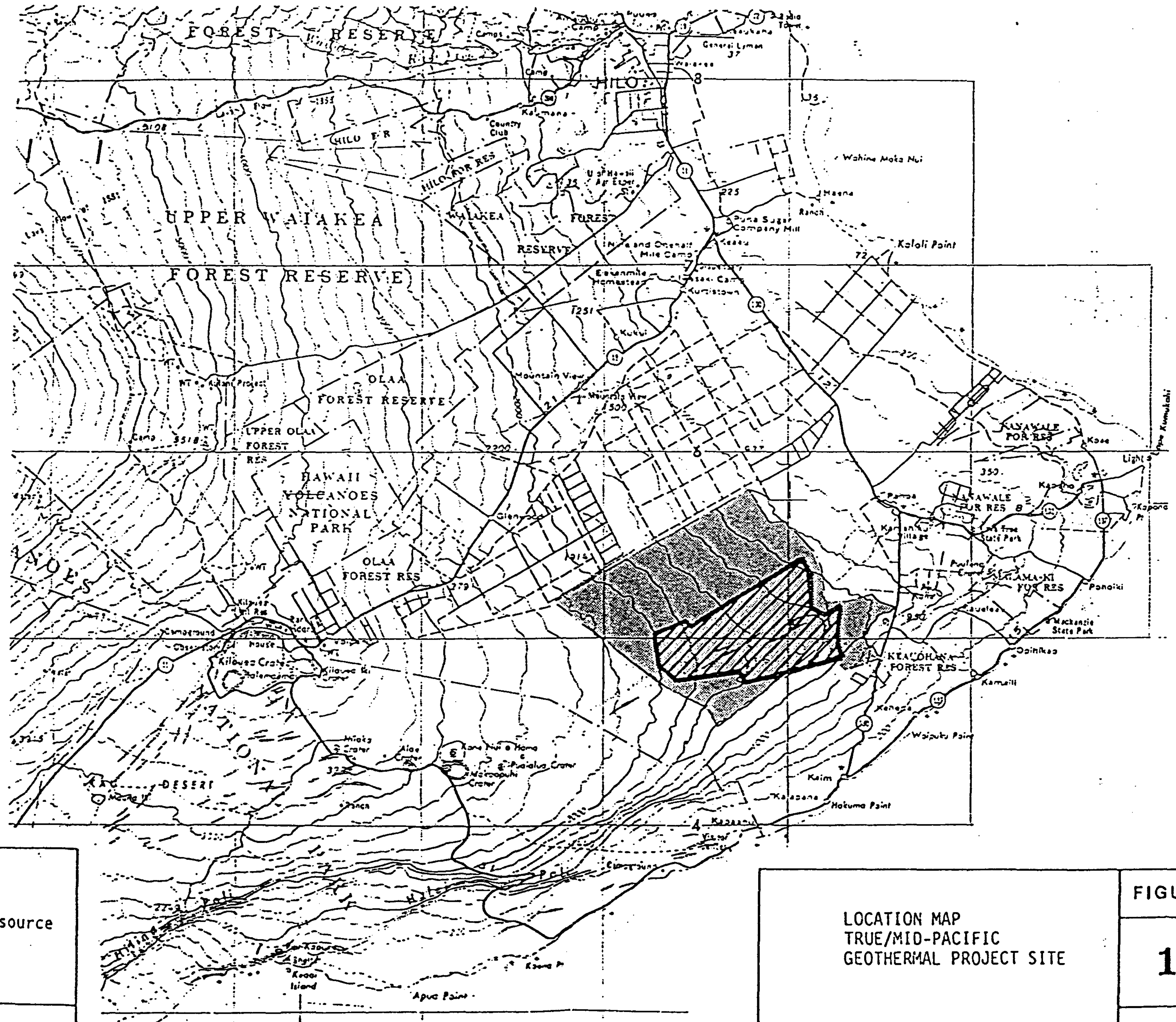
Emergency Plan

Objective. This emergency plan is designed to anticipate and plan courses of action to deal with possible medical emergencies and catastrophic events at the Kilauea Middle East rift zone geothermal project site, Figure 1, that could cause the health, safety and welfare of project personnel and other personnel present within the project site or residing near project activity to be seriously affected or endangered. Catastrophic events that could directly endanger personnel in the project site include volcanic activity (eruptions and lava flows, cracks and subsidence, earthquakes and faulting) fire, severe storms including hurricanes, and well blowouts. Natural events could result in the failure or destruction of facilities so as to cause extended venting of geothermal resources in which case there could be high levels of H_2S at the site of failure and exceedence of H_2S emmission limits at property boundaries. Medical emergencies are anticipated to include serious injury, burns, or over exposure to some process or by-product (e.g., H_2S) of project operations due to accidents, equipment or facility failure, or natural phenomena.

Safety policies, procedures and training, discussed in Appendix A, are designed to minimize the chances that natural events or project activities will cause injury or create a health hazard. This plan outlines those steps and procedures that would be implemented when certain events do occur (or appear likely to occur) that cause or could cause loss of life, serious injury or health hazards to personnel within or near project activity sites.

When there is high probability of a natural event occurring within the next 48 hours which threatens the health and safety of project personnel or other





LEGEND:

Geothermal Resource Subzone

Source:

LOCATION MAP
TRUE/MID-PACIFIC
GEOTHERMAL PROJECT SITE

FIGURE

1

personnel near project activity, project facilities or equipment, the drilling supervisor will assess his current operational situation to determine, depending on the likely time event will occur, whether any specific activities should be speeded-up, terminated, reduced, delayed in start-up or modified and whether emergency measures should be initiated in preparation to secure wells, break down and/or remove equipment and evacuate personnel. Personnel on site would be alerted as to the threating condition and given any specific instruction on preparing for or executing emergency procedures.

Management would be contacted and apprised of the situation and the actions taken thus far and those contemplated. All off-site project personnel would be contacted and given instructions to return to the site or to stand by in preparation to return if required. At present, there are no telephone lines into the project site. All communications will have to be via mobile phone.

The County Civil Defense Office (via the County Police Department) and other government and private agencies that would be involved in project emergency actions would be apprised of the situation and the actions being taken or planned and whether any assistance is required or anticipated. (See Emergency Contact List). In the event an emergency situation threatens public health or safety, the County Civil Defense office will establish a command post for the use of all public safety officials and for liaison with project management and technical personnel. Civil Defense will coordinate release of information to the public concerning any public hazard (i.e., outside the project site). The drilling supervisor and project management personnel will be available on a 24-hour basis to provide liaison with Civil Defense and provide updates on conditions relevant to the hazard to the public.

Specific Events

1. Volcanic Activity

   In the event of an eruption or impending lava flow, the Operations Supervisor will be in constant communication with Hawaii Volcanoes Observatory (HVO) so that the immediate threat to the drilling operation may be assessed. Volcanic eruption reports may also be obtained from HVO recordings at 808-967-7977. It is important to determine how much time is available to secure a well that is being drilled since the time required to temporarily close a well depends greatly on the depth of the well. The drilling industry has responded to these threats with technology and tools to secure wells that are in various states of drilling or completion in relatively short periods of time. These tools, commonly referred to as "storm plugs" or bridge plugs" are stored at the drilling site so that installation can occur on short notice in the event of an impending hazard.

   Depending upon the time estimate on the occurrence of the threating event, a plan will be executed to ensure the safety of all personnel, as well as the security of the hole and drilling equipment. If sufficient time exists, steps will be taken to allow removal of expensive drilling equipment to a safe location. Table F-1 lists the priority and method of evacuating equipment.

   Once a plan of action has been undertaken, the Operations Supervisor will maintain contact with HVO to monitor the development of the volcanic

PRIORITY ORDER OF MOVEMENT	RIG ITEM	METHOD OF MOVEMENT	COMMENT
1	Generator Unit	Flat bed truck with winch and tail roller	Unit could be disconnected and dragged on flat bed quickly.
2	Fuel and Fuel Tanks	Tanker truck for fuel; Flat bed truck for tank	Fuel would be pumped off onto a transfer tanker truck and the storage tank moved a a low priority item.
3	Air Compressor	Tractor truck without trailer	Units are easily disconnected and can be moved with a tractor while generator unit is being moved.
4	Mud Pumps	Flat bed truck with winch and tail roller	Unit disconnects easily after draining mu to sump.
5	Cementing Unit	Tractor truck without trailer	Unit can be maintained disconnected off location to be transported to the site an connected only when needed.
6	Electric Logging Unit	Flat bed truck with winch and tail roller	Unit usually maintained disconnected off location until needed when it is transport to the site and connected for use.
7	Mud Logger's Trailer	Pick-up truck	Unit disconnects quickly and can be moved at any time with pick-up truck.
8	Abatement Equipment	Tractor truck without trailer	Unit maintained disconnected off location while not in use, however, when in use, disconnects easily.
9	Accumulator	Flat bed truck with winch and tail roller	Disconnects quickly for easy movement.

Table 1 to
Emergency Plan

ORDER OF MOVEMENT	RIG ITEM	METHOD OF MOVEMENT	COMMENT
10	Catwalk Racks and Drill Pipe	Forklift and Flat bed truck	Drill pipe in hole or derrick remains on location. Pipe on ground can move quickl with forklift.
11	Parts House/ Change Room	Flat bed truck with winch and tail roller	Only connected to rig with electric wire. Disconnects quickly.
12	Doghouse/Tool-Pushers Trailer and Air Com-pressor Trailer	Flat bed truck with winch and tail roller/Pick-up truck.	Disconnects quickly for easy movement. Low priority item.
13	Water Tanks	Flat bed truck with winch and tail roller	Water is drained to sump and tank is moved as a low priority item.
14	Air Drilling Muffler	Crane and flat bed truck	Moved as low priority item.
15	Mud Tanks	Flat bed truck with winch and tail roller	Mud is drained to sump and tanks moved as low priority item.
16	Sub-structure, Drawworks and Derrick	Crane and flat bed trucks	Low priority items since they require too much time to move. Sub-structures elevate draw works and derrick base on pedestal approximately 26' above ground level.

event as it proceeds, to determine if the chosen plan of action should continue or be amended.

The first priority response to the threat as related to in-progress drilling operations is concerned with the safety of all project personnel and near-by residents that could be impacted because of damage or failure of project systems and facilities.

The next order of priority is to leave the well bore in a safe condition. The well bore can be isolated from the ground surface safely with the installation of a bridge plug or storm plug. This oilfield tool is inserted into the well bore on the drill pipe and set at any depth in the casing. The drill pipe below the plug can be safely suspended from the plug. The drill pipe above the plug can be unscrewed and removed or left in place. By installing this plug into the well bore and closing all surface well head valves the hole can be isolated to prevent movement of fluids or gases from the lower potentially productive zones to the surface as well as prevent surface fluids from moving down the hole.

The bridge plug is built to withstand high pressures and temperatures and is available in various sizes. Drilling plans call for plugging tools such as these to be kept on-site at all times while drilling below the 13-3/8" casing string. All rig personnel will be familiar with all aspects of running and setting these tools, so that if an emergency occurs the well bore can be safely secured and isolated before personnel leave the rig. These tools can also be easily removed after the hazardous condition has ended and drilling operations are resumed.

All valves and well heads are tested at the factory to hold pressure at 2,000 PSI and designed to withstand temperatures in excess of 2,500 degrees F. compared to 2,000 degrees F. lava temperature. In the event that the entire well head assembly is destroyed by a massive flow, the subsurface bridge plug would isolate the well bore from the lava. Should continuing volcanic activity prevent continuing operations at the site of an uncompleted well, the well will be properly plugged by setting the required cement plugs above the bridge plug.

The last priority would be the protection of the drilling equipment. Certain portable pieces of drilling equipment and rig components would be removed and relocated to a safe area if time permits. These components will be selected by the supervisor at the time the threatening condition is manifested and depending on the status of operations at the time. Priorities in evacuation and the equipment that will be needed in the event of emergency evacuation will be updated as project development proceeds. Trucks and cranes necessary for a move would be prearranged so that they will be available in the event they are needed.

The following sequence of operations will be followed in total or in part, based on the time factor allowed by the emergency condition. (It should be kept in mind that Hawaiian lava flows are non-explosive and therefore good estimates of lava flow direction and speed can be made when the vent is up the rift zone or above the project site.)

1) Assess the emergency, consulting with HVO to determine speed and direction of the lava flow. If the situation warrants immediate action, close all surface valves and evacuate all personnel from the location.

2) If time permits, contact operators of cranes and trucks and arrange for removal of designated drilling equipment.

3) If the emergency occurs while drilling, raise the drill string from bottom at least 400 feet and install the bridge plug on the drill string. Run the bridge plug into the well bore to a depth of approximately 300 feet and set and test the bridge plug in 13-3/8" casing. If time allows, remove the drill string. This procedure requires about one hour to accomplish.

4) If the drill string is out of the hole when emergency occurs, install bridge plug in the well bore to a depth of 300 feet. Set and test the plug, then remove the drill string above the plug if time permits. This procedure requires half an hour.

5) Close all surface valves and blowout preventers to isolate the well bore.

6) If time allows, remove designated drilling equipment with cranes and trucks.

7) When safe, return to the drill site, inspect and clear well head and rig area, if feasible, screw on drill pipe, remove the bridge plug, remove bridge from drilling assembly, and resume drilling.

2. <u>Earthquakes</u>

Since no detection systems have yet been devised to predict or warn of an impending earthquake, such events have to be assumed and engineering design of facilities and systems planned to withstand the magnitude of potential earthquakes in the area with a comfortable margin of safety. For construction standards, Hawaii is considered to be in Zone 3.

Regardless of design criteria, it is still possible that personnel could be injured in an earthquake and systems could fail or be severly damaged which in turn could cause injury or create a health hazard. In such situations, the drilling supervisor, or other personnel on the scene will have to take immediate action to deal with any injured personnel and to correct any failed system that is causing or posing a danger to the health and safety of personnel in the area. Procedures for evacuation of personnel and coordination of emergency conditions with medical facilities, the Director of Civil Defense, Hawaii County, and other agencies would follow those used for volcanic activities.

3. Fires

The project area is located in an area that may be susceptible to fast moving fires. Project personnel will be continually instructed on the precautions necessary to avoid creating fires or fire hazards and to be alert at all times for detecting and reporting fires initiated anywhere in the area.

Fire suppression systems for fighting fires at and near the drilling site will be established. The water catchment pond will provide the means of fighting fires in and adjacent to the drilling site. Portable extinguishers for chemical and fuel fires will be located at several locations in the drilling site. In the event of a fire, project personnel will take immediate action to extingish the fire or control it while additional fire fighting means or support can be applied. Fires will be reported to the Fire Department emergency number (961-6022). Fire fighting equipment is stationed at Keaau, with an additional fire truck at Pahoa.

Should a major forest fire approach the drilling site, the drilling supervisor will make the same evaluations concerning current operations and evacuation of personnel and equipment as for an impending or actual volcanic eruption. In addition, special attention will be given toward removing materials that could cause explosions and severe hazards to personnel remaining in the area and intensifying of the forest fire. The Fire Department will be apprised of conditions at the project site periodically as long as the forest fire remains a threat.

4. Blowouts and Exposure to Excessive Levels of H_2S

Should a blowout occur through the wellhead assembly or below the surface, the drilling crew's first response is to immediately detetermine that no one was or is about to be injured as a result of the blowout and if so, to take quick action to render assistance. Alertness for excessive H_2S levels is paramount and protective masks and clothing may need to be worn by all personnel in the area that may be exposed to extensive H_2S levels or the hot, high pressure geothermal fluid/steam. The drilling crew could be subject to sudden excessive levels of H_2S due to a blowout, or through the blooie line when drilling with air. Speed is essential in rescuing an individual exposed to levels of H_2S which could be life threatening in 30 minutes or less. Inhalation of H_2S at levels of 500-600ppm at, or immediately adjacent to the emission point, could constitute such an emergency. However, any levels over 50ppm would be treated as dangerous and personnel safety precautions and procedures would be implemented while actions are taken to control/reduce the H_2S emission levels. Should excessive emissions occur and overcome an individual, the emergency rescue procedures to be followed, as described in Tab A to this Appendix, represent practices recommended by the Workmen's Compensation Board, Alberta, Canada and the American Heart Association. The procedures were compiled and printed in publication No. M10, Department of Conservation, Division of Oil & Gas, State of California.

After assuring that personnel are safe from a blowout (or an event of excessive levels of H_2S in the area), the drilling supervisor will assess the blowout to ascertain the cause and what immediate steps can be taken to contain, control or secure the blowout. Management will be notified of the situation so that immediate action can be taken to obtain technical assistance and/or special equipment as may be required. Similarly, if excessive H_2S levels are emanating from the blooie line, immediate adjustments will be made in the injection of H_2S abatement chemicals to reduce the H_2S emissions to normal controlled levels.

In the event of a blowout, downwind H_2S monitors will be read as a precautionary measure to determine whether based on existing meterological conditions the H_2S concentrations could be expected to impact residences near the project area. The Director, Civil Defense, County of Hawaii and the Director of the Health Department, or designated representative, will be notified of the blowout, the nature of the blowout, the levels of H_2S being monitored downwind of the well, the current meterological conditions, estimates on what concentration levels are likely to exist at the nearest residential boundary, and a tentative estimate, if possible, of the time required to secure the blowout. Off-site personnel will be contacted to return to the site if required.

Any changes in the conditions first reported to Civil Defense and the Health Department will be promptly reported to those agencies.

5. MEDICAL EVACUATION. In case of an injury at an exploration well site during construction, drilling, or testing, there will be first aid services to handle minor injuries. Serious injuries that require immediate medical attention must be provided at appropriate medical centers. Assistance for these injuries will be requested via the Fire Department emergency number, 961-6022. The closest hospital is located in Hilo. An ambulance will require approximately 40 minutes to make the trip from Keaau to the project site. This will be the primary method of medical evacuation, however, other methods are available. Private vehicles could be utilized, however the patient would not have the services of a paramedic until the ambulance was met. Helicopter evacuation may be feasible if one is readily available in the area from the company or companies with which operating agreements have been concluded on providing such emergency service.

In case of serious burns, victims may have to be transported to Oahu (Straub Clinic) for treatment or even to a recognized burn treatment center such as Sherman Oaks, California.

6. <u>POLICY ON THE NOTIFICATION OF SUBSTANTIAL RISK</u>

The Toxic Substances Control Act (TACA) requires under Section 8 (e) that any person who obtains information that reasonably supports a conclusion that any chemical substance or mixture presents a substantial risk to health or the environment should report this to the EPA.

To comply with these requirements, the Policy of the "Operator", TRUE Geothermal Energy Company, is as follows:

> Employees who acquire information that reasonably suggests that a chemical substance or mixture used in project operations may present a substantial risk to health or the environment will inform the operator's Administrative Coordinator. This action should be taken as soon as such information is received, without awaiting a final report, conclusions, or results of subsequent or confirmatory studies.
>
> The Administrative Coordinator will inform and consult with appropriate Environmental Affairs, Legal and management personnel and will coordinate all reports to the EPA. Any reporting to the EPA

will be done in consultation with appropriate operating company management.

Copies of reports of all toxicological studies and all investigatory studies made relating to health or environmental concerns shall be evaluated in regard to TSCA §8 (e) reporting and for filing with other health and environmental information.

The persons initially bringing the information to the attention of management will be informed of the decision on filing a notice of substantial risk.

Failure to comply with the provisions of this policy could lead to Federal penalties under TSCA.

EMERGENCY RESCUE AND FIRST AID PROCEDURES

FOR

VICTIMS OF EXCESSIVE H_2S INHALATION

(TO BE POSTED IN A POSITION CLOSE TO THE DRILLING SITE)

TAB A
Appendix F
Emergency Plan

Rescue and First Aid Procedures

For Victims of Excessive H_2S Inhalation*

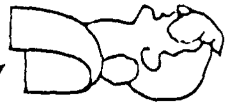
1. SPEED IS ESSENTIAL IN RESCUING A VICTIM AND IN ADMINISTERING FIRST AID.

2. THE RESCUER DONS SELF-CONTAINED BREATHING EQUIPMENT BEFORE APPROACHING THE DANGER AREA AND THE VICTIM. WHEN POSSIBLE, THE RESCUER SHOULD HAVE A PARTNER ON A LIFE LINE.

3. THE RESCUER IMMEDIATELY MOVES THE VICTIM TO FRESH, PURE AIR WHILE OTHER PERSONNEL OBTAIN THE RESUSITATOR FOR USE ON THE VICTIM, AND CALL FOR MEDICAL ASSISTANCE.

(SEE SUCCEEDING PAGES, PARAGRAPHS 4 THROUGH 13, FOR FIRST AID PROCEDURE.)

* These procedures represent practices recommended by the Workman's Compensation Board, Alberta, Canada, and the American Heart Association.

*4. Airway  or 

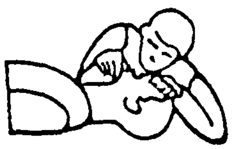
If you find a collapsed person, determine if victim is conscious by shaking the shoulder and shouting "Are you all right?" If no response, shout for help. Then open the airway. If victim is not lying flat on his back, roll victim over, moving the entire body at one time as a total unit.

To open the victim's airway, lift up the neck (or chin) gently with one hand while pushing down on the forehead with the other to tilt head back. Once the airway is open, place your ear close to the victim's mouth:

- Look – at the chest and stomach for movement.
- Listen – for sounds of breathing.
- Feel – for breath on your cheek.

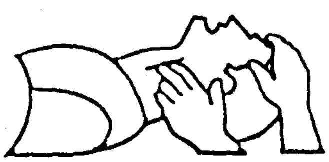
If none of these signs is present, victim is not breathing.

If opening the airway does not cause the victim to begin to breathe spontaneously, you must provide rescue breathing.

5. Breathing  

The best way to provide rescue breathing is by using the mouth-to-mouth technique. Take your hand that is on the victim's forehead and turn it so that you can pinch the victim's nose shut while keeping the heel of the hand in place to maintain head tilt. Your other hand should remain under the victim's neck (or chin), lifting up.

Immediately give four quick, full breaths in rapid succession using the mouth-to-mouth method.

6. Check Pulse 

After giving the four quick breaths, locate the victim's carotid pulse to see if the heart is beating. To find the carotid artery, take your hand that is under the victim's neck and loc t the voice box. Slide the tips of your index a c middle fingers into the groove beside the voice box. Feel for the pulse. Cardiac arre can be recognized by absent breathing a c an absent pulse in the carotid artery in the neck.

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For Infants and Small Children

Basic life support for infants and small chil e is similar to that for adults. A few important differences to remember are given below.

Airway

Be careful when handling an infant that you do not exaggerate the backward positior of the head tilt. An infant's neck is so pliable that forceful backward tilting might block breathing passages instead of opening th m.

Breathing

Don't try to pinch off the nose. Cover both e mouth and nose of an infant or small child who is not breathing. Use small breaths with less volume to inflate the lungs. Give one si a breath every three seconds.

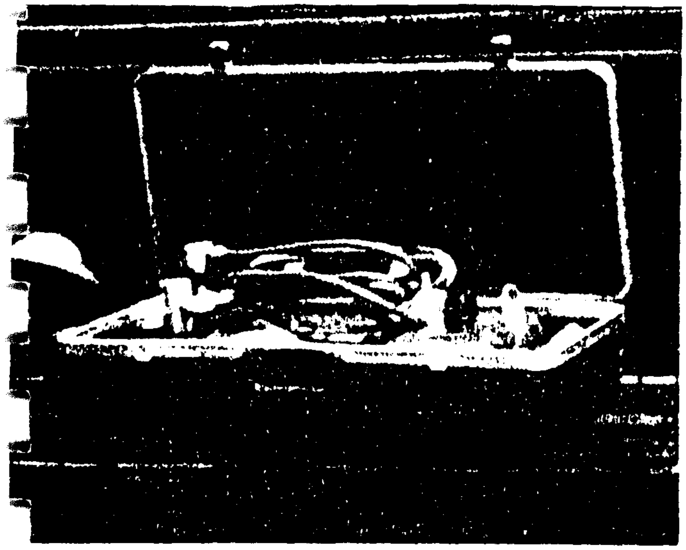
Check Pulse

The absence of a pulse may be more easily determined by feeling over the left nipple.

7. *If you CAN find the pulse,* continue rescue breathi until victim revives or the resuscitator is reached. (E ercise care due to possible lung congestion.) According to the American Red Cross rescue breathing instructions, you should:

- Repeat breaths about 12 times a minute for an adult or 20 times a minute for a child.
- Establish a rhythm.
- If victims's stomach rises, press it gently to remove air.
- As patient revives, watch closely. Treat for shock

If you CANNOT find the pulse, the victim needs CPR, Cardiopulmonary Resuscitation. CPR should be administered ONLY by a person properly trained and certified. It is too complicated to be taught from printed pages alone.



A resuscitator. *Photo by Murray Dosch.*

9. The Pneolator is an instrument that performs artificial respiration with an automatic, predetermined pressure on inhalation, and without suction on exhalation. This most nearly represents normal respiration and has been selected by medical authorities as the method of choice in restoring breathing.

Once the patient is breathing, the Pneolator becomes an effective oxygen inhalator by a simple adjustment. If the air passage is obstructed by mucous or foreign material, a warning is immediately given by a chattering of the cycling valve, and the Pneolator provides an aspirator for removing the obstruction. The Pneolator can be taken with a victim to the hospital.

NOTE: The small oxygen bottles carried by most ambulances are not the type required for a Pneolator. The 21 cubic foot bottle of oxygen in the Pneolator should be checked and filled to capacity *before* all well testing operations. Furthermore, it is strongly recommended that an extra supply of oxygen (a commercial tank) be kept on hand as a "standby" supply.

This large oxygen cylinder can be hooked up to the resuscitator while it is being used to increase the volume of oxygen that is available for use should there be more than one victim overcome.

Keep victim warm and quiet, but never unattended.

10. A person who has been overcome by H_2S gas and revived could go into shock. Because of this, take the victim to a doctor at once. Patients should be kept under medical observation until the doctor declares them fit to return to work.

11. A patient breathing normally may be given stimulants such as tea or coffee. (Alcohol is a depressant).

12. If eyes are affected by H_2S, wash them thoroughly with clear water. For slight eye irritation, cold compresses will help.

13. Once a victim is removed to fresh air and normal respiration restored before heart action ceases, rapid recovery may be expected.

In cases of slight or minor exposures, where the worker has not been totally unconscious and wants to return to work after a short rest period, it is recommended that duty be postponed until the following day. Reflexes may not have returned to normal, and the person could be subject to injuries from other work hazards.

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